

The Antique Wireless Association Review

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THE AWA REVIEW

Volume 23
2010



Published by
THE ANTIQUE WIRELESS ASSOCIATION
PO Box 421, Bloomfield, NY 14469-0421

<http://www.antiquewireless.org>

Devoted to research and documentation of the history of wireless communications

Antique Wireless Association
P.O. Box 421
Bloomfield, New York 14469-0421

Founded 1952, Chartered as a non-profit corporation by the State of New York

<http://www.antiquewireless.org>

THE A.W.A. REVIEW

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ISBN 0-9741994-7-8

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Printed in Canada by
Friesens Corporation
Altona, MB

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Foreword

The exciting news again this year about the *AWA Review* is that it is still distributed free of charge to all AWA members. It is another of the benefits of membership, without raising the dues. The *AWA Review* is the AWA's peer reviewed historical journal. This change in *AWA Review* distribution is again made possible by a generous donation from a long standing AWA member who wishes to remain anonymous. This has the effect of exposing very many members to the content of the *AWA Review* who would not have seen it under the former distribution. It reflects our donor's commitment to the written historical record about wireless in addition to the AWA members' evident enthusiasm for preservation and acquisition.

This promises to be another strong issue of the *AWA Review*. A list of this year's *AWA Review* contents is:

- **'If it be Permissible to Prophecy Wildly': A note on Richard Threlfall, Hertzian Waves and the Drafting of the Australian Constitution** by Graeme Bartram. Bartram outlines the history of Sir Richard Threlfall, the Cambridge-educated first Physicist at Sydney University. Revealing just a trace of national pride, he tells how Threlfall came to meet Heinrich Hertz in Germany and to realize that Hertz's experiments would likely be applied to wireless signalling.
- **Communications Related U.S. Army Recruiting Posters** by David and Julia Bart. Recruiting posters had their beginnings at around the same time as electric communication. The Barts explain how the poster was instrumental in appealing to the public, stimulating national unity, and promoting military recruiting. Their interesting article here is drawn from material in their new book on the subject.
- **The Zenith 1000Z Stratosphere: Zenith Radio Enters the Black Dial Era in Grand Form** by Martin W. Blankinship. The energy and creativity of Commander Eugene F. McDonald was expressed in many ways. One of the most impressive was the 1000Z Stratosphere, a culmination of Zenith deluxe models. Blankinship describes the design, production and restoration of this impressive set.
- **The Earliest Heathkits and a Database for the Years 1947 - 1956** by Erich Brueschke. Not only does this article detail the entire kit production of the Heath Company to 1956, it offers a philosophy of collecting and its social significance. To top it off, Brueschke provides the definitive database of Heathkits.

- **Swan Island, its Radio History, including the CIA and the Revenge of United Fruit** by Bartholomew Lee. This is as lively a presentation as we have come to expect from Lee. It interlaces the political and radio histories of the Caribbean, giving us a sense of how each influenced the other.
- **SCR-54/A (BC-14/A) Radio Receiver Sets for Artillery Spotting** by Eric P. Wenaas. This is a thorough treatment of First World War American artillery spotting from aircraft, and the radio receivers that made it happen. It covers spotting requirements, the evolution of receivers to address the needs, and the hardware furnished by the various government contractors. Finally it describes how collectors can distinguish between original sets and those with a mixture of parts from several sources.
- **Early Submarine Cable Instruments and Apparatus** by Bill Burns. For years we have known about Burns' excellent web site about the Atlantic Cable. Now Burns describes the major advances in communications engineering between 1850 and 1910, just prior to the availability of the vacuum tube.
- **British Army World War Two Anti-Aircraft Radar** by Crawford MacKeand. MacKeand lovingly recalls the early radar equipment and the eccentricities of its operation during the war. Examples of it remained in military training schools after the war, which was where MacKeand first encountered them.
- **Mirror Screw Television: 25 Years of Experience** by Peter F. Yanczer. It seemed that every year one visited the AWA Conference exhibits, Yanczer would be there demonstrating the latest enhancement to his mirror screw models. Well, perhaps it was not quite that often. Here Yanczer gives us a detailed overview of the things he learned in 25 years of replicating mechanical television sets. From this he infers the reasons for the fate of the technology.
- **Wireless and the Sinking of the Republic, 1909** by Jack Binns and Virginia Utermohlen Lovelace. Virginia Lovelace has her grandfather's unpublished biography including the role of wireless in the rescue of passengers aboard the *Republic* in 1909. Her grandfather was Jack Binns, the wireless operator aboard the *Republic*. This is a very early and dramatic story of rescue at sea, and we are privileged to have it in Binns' own words. This article is excerpted from Lovelace's forthcoming book on the subject which can be ordered from her by e-mail at v@jackbinns.org.
- **Letters to the Editor** by Eric Wenaas, Alfred Stoll and Mike Murphy.

Our sincere thanks are due to these authors for their fine and often painstaking efforts.

We continue to use the services of experts in the field as peer reviewers. We believe that this process raises the overall quality of the *AWA Review*. The reviewers for this issue are:

John Dilks, Bill Holly, Bruce Howes, Ivor Hughes, John Jenkins, Russ Klienmann, Robert Lozier, Allan Pellnat, Tom Perera, Jerry Simkin, Marsha Simkin.

We thank them for their insight and careful work. AWA members and others with an interest in wireless communication history are encouraged to submit manuscripts to the *AWA Review*. A section titled Tips for Authors follows. We try to make the publication effort more collaborative than challenging. The single most important message in this regard is to contact us early if you are considering writing an article.

A cumulative index of Tables of Contents of all previous issues of the *AWA Review* is maintained on the website of the AWA at <http://www.antiquewireless.org>. The index is found on the Museum page.

It is my distinct pleasure to bring you this volume of the *AWA Review*. I hope you enjoy it. I hope it stimulates you to think of new ways in which you can contribute to this satisfying hobby. I look forward to receiving your manuscripts for next year's volume.

Robert P. (Bob) Murray, Ph.D.
Editor
Vancouver, BC, Canada

Tips for Authors

The *AWA Review* welcomes any submitted article on aspects of wireless communications history. In general, shorter articles can be directed to the *AWA Journal* and longer manuscripts to the *AWA Review*. If you are in any doubt about where your article should best appear, please contact either or both editors.

The *AWA Review* will accept and publish Letters to the Editor as space permits. This will be a suitable way to submit your comments if you wish to take issue with a recent article published here, or make other brief comments on wireless history matters. Letters will not be peer reviewed, but will be edited, primarily for length at the discretion of the Editor. The Editor reserves the right to publish responses. Galleys of letters to be published will not be returned to the author. Text is limited to 400 words and no more than 10 references.

For first time authors, articles can be prepared with the help of a more experienced co-author, or the editor can help with the text in the editing process. Members with an interesting story to tell should not be discouraged by a lack of writing experience. The *AWA Review* will accept manuscripts in any clearly prepared writing style. A short style manual produced by the American Radio Relay League is available on request. *The Elements of Style* by William Strunk Jr. and E.B. White is available in most public libraries. Reference material should be cited within the text of the article in any of the accepted reference styles. Reference lists should include all of the sources mentioned in the text. Writers should look at the articles in this volume or in recent previous volumes for examples.

Articles submitted to the AWA will be laid out on the pages in a style made consistent within the entire publication. Therefore, please do not arrange your illustrations on each page but rather send the text in a file separately from the files for each illustration. This requirement applies equally to the Journal and the Review. (see, for example, "From the Editor" in the *AWA Journal*, April 2006, pages 4 & 5.) Text files can be prepared on any word processing software, but preferably on Microsoft Word. Please do not include idiosyncratic text styles (such as small caps) since these will need to be stripped out when your article is prepared for publication. Illustrations are best sent as .JPG or .TIF files with a resolution of around 300 dpi. JPG files should be Standard (not Progressive). Files can be submitted as e-mail attachments directed to the editor.

Manuscripts submitted to the *AWA Review* will be peer reviewed. That is, they will be forwarded to one or more AWA member(s) with expertise in the area of the article. The reviewer's comments will be returned to the author(s) anonymously, so that the reviewer is comfortable with being candid in his or her response. After the reviewers' comments have been addressed by the author, the article will be type set in a publishing software (currently Adobe InDesign), following which galleys will be returned to the author. This will be the last stage at which errors can be corrected. Normally only one set of galleys will be sent.

Articles submitted to the *AWA Review* should be developed in concept not later than early January of the publication year. A first draft should be submitted around March. The editor's deadline for submission of the completed volume to the printer is July 1, so that a final draft is expected around May 1. Articles not submitted on this schedule will be rescheduled for the next year's volume. For more information contact:

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"If it be Permissible to Prophecy Wildly..."

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ABSTRACT

For 120 years the name of Professor Richard Threlfall has remained a passing reference in the history of radio.¹ In radio circles he is best remembered for his 1890 'prophecy' in which he speculated about the use of Hertzian waves in signalling. However this belies a distinguished academic, industrial and public record of achievement. This paper therefore commences with a review of Threlfall's significant contributions to the scientific and engineering communities during his lifetime. Against this background a close examination of the genesis of the 'prophecy' is undertaken to show the development of Richard Threlfall's thinking in the field and how he arrived at the conclusion he did about the possibilities inherent in the discovery of Hertzian waves.

THE CAREER OF SIR RICHARD THRELFALL²

Richard Threlfall was born on 14th August 1861 at "Hollowforth" in the small village of Woodplumpton, Lancashire in England. A self-taught experimenter, as a boy he managed to blow off the third and middle fingers of his left hand as well as the top joints of his right thumb and index finger in a backyard explosion!³ His experimental bent continued when he moved to Clifton College in January 1873, much to the delight of his classmates. A person of considerable physical presence, Threlfall actively participated as a member of the school rugby football team, a sport he would continue to play into adulthood.



Figure 1 - Richard Threlfall circa 1882

In 1880 he obtained a scholarship to Cambridge University. Richard Threlfall had a distinguished undergraduate career at Cambridge where he sat for Part I and Part II of the Natural Science examinations in 1882 and 1884 respectively obtaining a First

Class Degree in both. The Natural Science examinations undertaken by Threlfall placed a strong emphasis on experimental as opposed to mathematical physics. This suited Threlfall both in terms of his own interests and also gave him valuable exposure to a range of experimental methods. He later noted that "I appreciated the necessity of learning such of the mechanical arts as are useful in the Laboratory. I therefore

systematically spent my holidays in acquiring them. I now know the ordinary details of mechanical engineering; optical work, glass blowing, and telegraph construction.”⁴ In 1884 two Assistant Demonstrators joined the Cavendish Laboratory staff at Cambridge to support the undergraduate experimental work, one of whom was Richard Threlfall himself.

As an Assistant Demonstrator Richard Threlfall worked closely with the future Nobel prize winner J.J. Thomson who regarded him as “one of the best experimenters I ever met” and missed his presence at the Cavendish Laboratory after he left for Australia in 1886 to take up the position of the first Professor of Physics at the University of Sydney.⁵ Thomson had also co-authored two academic papers with Threlfall in 1886.⁶ In private correspondence to Threlfall dated 13th April 1886 Thomson said:

“I cannot tell you how sorry I am you are going, every day I spend in the laboratory when you are not there makes me feel that on that Monday when we elected you [to the Professorship at the University of Sydney] I did the worst days

work for myself I ever did in my life.”⁷

Moving to Australia from Cambridge was a considerable career risk. Major scientific breakthroughs were regularly occurring in the northern hemisphere in the late nineteenth century and Australia was an isolated academic backwater. However Richard Threlfall was a man of extraordinary energy and tenacity who took on the challenge of his antipodean appointment. Coming from the Cavendish Laboratories at Cambridge Threlfall was shocked to find little in the way of such facilities at his new University. Lobbying the University Senate and the State Government he set to work establishing a new laboratory which was completed in 1888.⁸ Contemporary photographs show a well equipped workshop capable of the manufacture of a variety of laboratory and experimental apparatus. In addition the University of Sydney Physics laboratory day-book inventories show that there were adequate materials at hand to construct apparatus not available in Australia.⁹

In founding the Chair of Physics in Sydney Threlfall led a transition to experimental physics in Australia which much of the late nineteenth century scientific community was undertaking elsewhere. He quickly established himself, pursuing academic work as well as a number of important Government commissions. He continued to publish widely and maintained a strong network of contacts in Australia, Europe and the United Kingdom coupled with regular follow up sabbatical visits, including a notable meeting with Heinrich Hertz in Germany in early 1889. During his time in Australia Threlfall undertook experimental work on a wide range of topics including underwater explosions, dielectrics,



Figure 2. J.J. Thomson



Figure 3 - The Former Physics Building at the University of Sydney Built by Richard Threlfall in 1888

investigation of the properties of pure sulphur, advised Government on electrification of public utilities and headed a State Royal Commission into the problem of spontaneous combustion of coal in the hulls of ships. With J.J Thomson's support he published *On Laboratory Arts* in 1898, a compendium on laboratory techniques with a strong practical bent.¹⁰ As a full Professor he also continued his passion for rugby and played for the University team. In all he spent 12 years in Sydney and is still celebrated today as the first genuine Professor of Physics to reside in Australia.

During his 12 years in Australia Threlfall pursued three distinct lines of major experimental research. Firstly, his interest in explosives continued, with extensive experimental work taking place in Sydney Harbour over 3 years to measure the velocity of explosions in seawater.¹¹ In order to conduct these experiments Professor Threlfall drew together many local scientists and Government bodies in a way never seen before in the colony. A second major research project over 10 years involved the development of a quartz thread torsion balance used as a gravimeter. This was employed to measure gravity throughout the east coast of Australia. A paper

on the instrument itself was later presented to the Royal Society in London.¹² Threlfall's third major project related to the measurement of resistance of locally produced tree gums with a view to their commercialisation for electrical insulation. In the course of experimental work Threlfall developed a highly sensitive galvanometer which he claimed was capable of detecting currents of 3×10^{-14} .¹³ Reading Threlfall's papers today over a century after they were written one cannot but be impressed with the rigour and precision he brought to all his experimental work.

Threlfall's investigation of the electrical properties of matter such as tree gum led to extensive work on the use of sulphur as a dielectric in capacitor construction for use in alternating current circuits. In investigating the interactions of matter in electrical and magnetic fields, he went on to measure magnetic hysteresis losses in sulphur, selenium and paraffin. Years later he returned to this theme in describing the development of a highly sensitive voltmeter used to measure small high frequency currents, which was also capable of the detection of electromagnetic waves.

For personal reasons Richard Threlfall permanently returned to the United Kingdom in 1898, initially searching for an academic appointment but eventually joining the company Albright & Wilson as an electrochemical engineer based in Birmingham. Much of his work for the next 15 years was commercially protected but it is known that he devised a method for the electrolytic manufacture of sodium chlorate that was later used at Niagara Falls in the United States. His time in Australia was rewarded with an appointment as a Fellow of the Royal Society (F.R.S.) in 1899, a prestigious British appointment

granted only to those who have excelled in a field of scientific endeavour.

In 1914 he undertook his own research for the British Government on the use of helium in airships and as a result was appointed to the Naval Board of Invention and Research which was formed in 1915 to support the British war effort. This wartime work took him into the fields of developing the phosphorus bomb and smokescreens. He went on to serve on the British Government's Advisory Council for Scientific and Industrial Research for a further 10 years and was knighted in 1917 for his services to industry and Britain. He was awarded the Gold Medal of the Chemical Society in 1929 and died on 10th July 1932. One obituary notice observed "From the time he made his first experiments to the end of his life, for a period of over sixty years, there were very few working days in any year when Threlfall was not to be found for some period experimenting in his laboratory".¹⁴

THE HISTORICAL TREATMENT OF RICHARD THRELFALL'S 1890 'PROPHECY'

Historians of radio have often quoted Threlfall's famous 1890 statement about the possible use of recently discovered Hertzian waves in signalling but have never attempted to trace its origins nor determine whether he developed his thinking in the field beyond his initial insight. Placing Richard Threlfall's 'prophecy' in a proper historical context is therefore important in determining its place in the history of radio.

It was on 2nd January 1890 that Richard Threlfall stood before the Australian Association for the Advancement of Science (hereafter

AAAS) in Melbourne and delivered an address on 'The Present State of Electrical Knowledge' as President of Section A of the Conference. In the course of presenting his paper Threlfall made an extraordinary observation in relation to Hertz's recent discovery of electromagnetic waves and on the apparatus used in experimentation when he said:

"The apparatus itself may be modified and for some purposes improved by using two cylinders tipped with balls for the vibrator and placing them in the focus of a large parabolic cylindrical mirror so as to render the electric rays parallel. The receiver in this arrangement consists of a lengthy wire placed on the focal line of another mirror and interrupted by a spark gap in the usual manner. With this apparatus Hertz has imitated most optical effects. He has shown that the ordinary laws of reflexion of light are obeyed by these electric or "etheric" waves, and by constructing a large prism of pitch has found the index of refraction of that substance for long waves to which it is of course apparent. These measurements are all in close accordance with Maxwell's theory as could be expected, seeing the difficulty there is in making exact measurements of the position of so large a body as a resonator. It may be questioned whether greater accuracy might not be obtained by the use of Geissler tubes, coupled with some system of photography. These tubes have been successfully applied in Dr Lodge's laboratory, and *if it be permissible to prophesy wildly, we may see in this observation the germ of a great future development. Signalling, for instance, might be accomplished secretly by means of a sort of electric ray flasher, the signals being invisible to anyone not provided with a properly turned (sic)*

tube.”¹⁵ (emphasis added)

Others were certainly contemplating similar questions at about the same time. In private correspondence dated 1st December 1889 the German engineer Heinrich Huber had written to Heinrich Hertz asking “whether it would not be possible, according to your theory, to transmit the magnetic lines of force (the invisible ones, of course) over a distance? I am thinking in the first instance of transformers and the telephone”¹⁶ Controversy still surrounds the nature of Popov’s experimental work in Russia in 1890.¹⁷ In the March 1891 editorial of *The Electrician*, attributed to the Cambridge graduate Alexander P. Trotter, it was suggested that Hertzian waves could be used for ship to shore communications using “flash signals”¹⁸ and in 1892 Sir William Crookes published ‘Some Possibilities of Electricity’ where he proposed the use of electromagnetic waves for telegraphy and identified the principle obstacles to developing the technology as being the utilisation of reliable transmitters, tuned receivers and directional antennas.¹⁹ Coming only 18 months after Hertz had published his findings on the discovery of electric waves in June 1888, over a year before *The Electrician* editorialised about the possibilities of signalling and a full two years before Crookes, Threlfall’s statement to the AAAS is likely to constitute the earliest known published observation about the possibility of using Hertzian waves in signalling.

However history has generally treated Threlfall’s observation as a lone statement without context – looked upon as a one off or a lucky guess. An oblique reference to it first appears in 1899 as a footnote in J. J. Fahie’s *A History of Wireless Telegraphy 1838-1899*.²⁰

In 1907 Luciene Poincaré noted that “It was Professor R. Threlfall who seems to be the first to clearly propose, in 1890, the application of the Hertzian waves to telegraphy”.²¹ The statement then largely disappears from historical accounts of the development of wireless telegraphy, apart from the occasional biographical reference or obituary to Threlfall himself²², until it was resurrected in the 1960s by Charles Susskind in a series of articles about the origins of wireless.²³ More recently Threlfall’s statement has been re-examined but again portrayed as an isolated or speculative comment.²⁴

THE SABBATICAL TOUR OF 1888 AND 1889

In Australia Threlfall was alerted to the work of Hertz in private correspondence from J.J. Thomson, dated 3rd October 1888 when he was urged “you should read Hertz’s papers: they are very interesting.”²⁵ The timing of Thomson’s letter was perfect. Less than one month before Professor George Fitzgerald had outlined Hertz’s findings to the British Association in Bath²⁶ and Threlfall was in the process of planning an extensive sabbatical to Europe, the United Kingdom and the United States. Richard Threlfall could now do more than just read Hertz – he was presented with the possibility of meeting with Hertz in person.

Professor Threlfall left Australia in December 1888²⁷ with some of his first visits taking place in Germany where he met both Professor Helmholtz and Heinrich Hertz. Threlfall was no stranger to Germany and had spent the summer of 1880 learning German in Hanover as a student and in 1883 returned to work in the laboratories of Professors Fittig and Kundt at Strassburg learning experimental

method.²⁸ Threlfall's introduction to both von Helmholtz and Hertz probably relied on a letter provided by Professor Kundt, although he had also requested a letter of introduction to Helmholtz from Lord Rayleigh on 6th February 1889.²⁹ The meeting with Hertz in particular had a significant impact on Threlfall, as he later recalled after Hertz's premature death in 1894:

"In character Hertz was probably one of the most kindly and gentle men that ever lived, and just as his work has that particular directness and simplicity that characterises the work of Faraday and Darwin, so was he himself a man of much the same character – i.e. the highest reached by the human race."³⁰



Figure 4 - Heinrich Hertz

Threlfall was able to take advantage of a number of factors unavailable to other contemporary scientists in meeting with Hertz at that point in time. Firstly he was able to discuss Hertz's findings directly with him as Hertz would not visit the United Kingdom until late November 1890.³¹ Secondly Hertz had recently completed and published his work on the reflection of electric waves, a piece of work only available in English to other scien-

tists late in 1888. Thirdly Hertz's test apparatus was still available at Karlsruhe for first hand viewing prior to his move to the University of Bonn in April 1889 to take up the position of Professor of Physics.³² Finally his language skills gave Threlfall the opportunity to converse with his German colleagues in their native tongue.

What Threlfall would have seen at Karlsruhe was Hertz creating sparks across induction coil terminals and a dipole antenna that allowed the electromagnetic waves to be radiated across free space in his laboratory. In order to detect the electromagnetic waves Hertz used a resonant loop of wire as both a receiving antenna and detector.³³ In 1889 terms this technically represented apparatus capable of detecting wave interference in voltage standing waves in wires showing oscillatory energy at a single frequency coupled with the ability to observe both interactions between open circuits as well as resonance effects.³⁴ To demonstrate the optics-like properties of 'electric waves' Hertz had designed and built equipment to show rectilinear propagation, polarization, reflection and refraction.³⁵

It was on 10th February 1889 that Hertz had noted the increased frequency of foreign visitors to his laboratory in a letter to his parents³⁶ and on 27th February corresponded with Threlfall hoping he had a good journey after leaving Germany.³⁷ On the same day Hertz's diary records that he "Got glitter in my eyes"³⁸ after repeated demonstrations of his experiments to a succession of visitors, no doubt including Threlfall earlier in the month. Whilst later staying at Cambridge Threlfall responded to Hertz on 9th March indicating that he was due to depart for the United States and that "Everybody here is

very much interested in your work – I had to tell about my visit many times and everybody wanted to see the photograph.”³⁹

The reference to ‘the photograph’ creates two possibilities. One is that it represents the convention of the time whereby men of science exchanged personal photographs as a personal memento of a meeting or visit.⁴⁰ This view is supported by Hertz’s reference to “my photograph” in his correspondence to Threlfall dated 27th February 1889.⁴¹ The other possibility is more tantalising. It is known that contemporary photographs of Hertz’s apparatus were available and it is possible that Hertz had sent or given such a picture to Threlfall, thereby allowing for the accurate reproduction of the test apparatus. This latter view is reinforced by Threlfall sending Hertz technical photographs of Fresnel’s bi prism fringe from Australia

in November 1890 to be used by Hertz for lecture purposes.⁴² John H. Bryant⁴³ has identified that at least two remaining photographs of Hertz’s test apparatus dating from either 1888 or 1889 exist, demonstrating that it was possible for Threlfall to have a contemporary photograph of Hertz’s equipment with him at Cambridge in March 1889.

Threlfall’s correspondence with Hertz on 9th March 1889 contains another interesting reference to him “now do[ing] myself the honour of keeping my share of the contract”.⁴⁴ If Threlfall was one of the few scientists to have visited Hertz and viewed his experiments first hand in the months after his discovery of electromagnetic waves, then ‘the contract’ may well have been demonstrating techniques for the production and detection of these waves whilst visiting Cambridge in early 1889. In later cor-

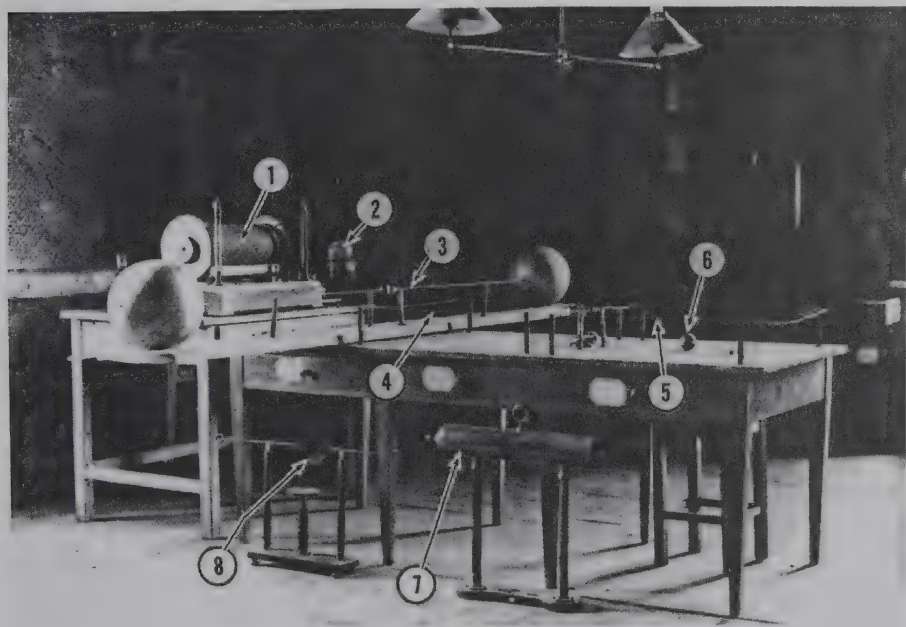


Figure 5 - Hertz’s experimental apparatus at Karlsruhe circa 1889. Numbers refer to: 1. Induction coil, 2. Primary battery, 3. Transmitter, 4. Loop receiver, 5. Loop receiver, 6. Metal sphere (to probe fields), 7. Large-area conductor, 8. High voltage discharger.

respondence dated 17th November 1890 Threlfall asked Hertz a more direct question regarding his own discoveries and their relationship to Maxwell's Theory when he said "I read your new 'Maxwell' with great interest – but have you not been too generous in attributing to Maxwell some ideas really due to Hertz?"⁴⁵ Hertz modestly replied "In the last sentence of your letter you asked whether I did not attribute to Maxwell some things belonging to me. I always endeavoured not to be pedantic about small things but I am not aware that I gave anything away of real value."⁴⁶

Prior to leaving Australia in 1888, Threlfall had followed the work of Oliver Lodge very closely.⁴⁷ One of Lodge's most celebrated demonstrations of Hertzian waves took place at the Royal Institution in London on 8th March 1889 during the lecture 'The Discharge of a Leyden Jar' soon after Hertz's breakthrough experiments became more widely publicised. Contemporary accounts by Lodge noted that "During the course of this experiment, the gilt paper on the wall was observed by the audience to be sparkling, every gilt patch over a certain area discharging into the next, after the manner of a spangled jar."⁴⁸ Importantly we know that Threlfall was also present in the United Kingdom at this time as he wrote to Hertz the next day from his Cambridge lodgings.⁴⁹ It is also clear that Threlfall regularly took the opportunity to attend public lectures on his later visits to the United Kingdom, as demonstrated by his participation in another Lodge lecture on 'Electric Signalling without Connecting Wires' held at the Physical Society in London on 21st January 1898 where he commented on experimental work he had undertaken on



Figure 6 - Oliver Lodge

The United States leg of Threlfall's 1889 sabbatical tour put him into direct contact with some of the leading experimenters in that country including Thomas Edison, George Westinghouse and access to the Edison and Westinghouse laboratories.⁵¹ The United States leg of the sabbatical took Threlfall to New York, Pittsburgh, Washington and Denver before departing from San Francisco aboard the R.M.A.S *Alamada* in May 1889.⁵² By 13th April 1889 Threlfall had spent two days at the Edison laboratories at Orange, New Jersey⁵³, met with Thomas Edison twice and had commented in private correspondence to J.J. Thomson on his discussions with Edison regarding the work of Hertz in the following terms:

"He tells me that in (/76 I think it was) he did a lot of things that Hertz has been doing (he told me some details) and thought he had discovered what he calls 'etheric force' (he is quite ignorant). These

experiments he published in the 'New York Tribune' of all places in the world (July 1876) and was prevented from following it up by Silvanus (sic) Thomson telling him that it was merely 'common' induction. He seems to have used a detector very like Hertz with the spark points under a microscope."⁵⁴

Edison's 'etheric force' had been the subject of significant controversy since it was first proposed in November 1875.⁵⁵ Edison and his staff had observed that a spark in a telegraphic circuit created sparks between two distant conducting objects. Edison, convinced he had discovered a fundamental new force, announced the discovery to the press and christened it the 'etheric force'. Whilst the initial press reports were supportive of Edison's claim, a level of scepticism soon entered into reporting. Moreover scientific and technical criticism was also levelled at Edison, with Elihu Thomson (not Silvanus) and Edwin Houston eventually convincing the scientific community in April 1876 that the sparks were the result of oscillatory high frequency currents. However what was understood after Hertz's work in 1888, and what Threlfall was reflecting in his comments to J.J. Thomson, was that Edison had actually detected high frequency electromagnetic waves.

THE OPTICAL ANALOGY AS A BUILDING BLOCK FOR THE 'PROPHECY'

Oliver Lodge's ideas continued to figure heavily in Threlfall's 1890 AAAS paper. Threlfall's paper recognised the work that Lodge had undertaken with his assistant James Howard on the optical properties of electromagnetic waves using large pitch lenses which was presented to the London Physical

Society on 11th May 1889.⁵⁶ E.J. Dragoumis had also undertaken contemporaneous experimental work in Lodge's Liverpool University laboratory in relation to the detection of electrical oscillations using Geissler's Tubes.⁵⁷ The Dragoumis article is no doubt the source of Threlfall's reference in the 1890 AAAS paper to the use of Geissler tubes for the detection of Hertzian waves in signalling. A short letter to the editor submitted by Lodge and published in *Nature* in July 1888⁵⁸, in which the possibility of using photographic techniques to capture lightning flashes was proposed, may have been a possible source for Threlfall's reference to "some system of photography" being used in conjunction with Geissler tubes for the detection of Hertzian waves in the 1890 AAAS paper.

George Francis Fitzgerald, Professor of Physics at the University of Dublin, commenced his own experimental work on the extension of Hertz's optical work in conjunction with Fred Trouton in October 1888.⁵⁹ The results of these studies were published by Trouton in two articles in *Nature* in February and August 1889 respectively. The articles focused on extending the work of Hertz to further testing of reflection on glass, polarization analysis and investigating propagation of electric waves in water. In the second paper, when discussing the action of the "vibrator" in relation to the dispersion of electric waves, Trouton commented that "It might be interesting to investigate whether these slow vibrations could cause dissociation, and thus lead to a photographic method of observing them."⁶⁰ Remaining evidence shows that Threlfall corresponded with Fitzgerald⁶¹ and was aware of the work of Fitzgerald and Trouton, as he cites it at two

places in the 1890 AAAS address and was also aware that detection of electromagnetic waves is critical experimentally.⁶² Trouton's suggestion of a photographic method may have also contributed to Threlfall's suggestion of "some system of photography" being used in a future signalling application.

Modern critiques of Threlfall's 1890 statement stress the inappropriate use of an optical analogy when describing the possibility of signalling using Hertzian waves. Sungook Hong for example generalises when he says "The physicists ... were preoccupied with optics. Quasi-optical questions, optical devices (such as polarizers and diffraction gratings), and short waves were standard features of physical experiments with Hertzian waves."⁶³ However these critiques do not entirely stand up when one considers that the early experimenters were actually dealing with microwaves and not the longer wavelengths we later associated with the development of wireless telegraphy after 1900. John F. Ramsay argued persuasively in the 1950s that Hertz and those who closely followed him were in fact the founders of microwave optics and as a result "we find the Hertzians making and using polarized mirrors, 'cutoff' metal-plate gratings, quarter-wave and half-wave plates, artificial dielectrics, microwave absorbers, prisms of wax, ice, or liquid filled, or of artificial dielectric, totally reflecting prisms, lenses of sulphur, ebonite, wax, pitch, and so on, a wealth of microwave components."⁶⁴ Even Marconi's early patents relied on the use of a cylindrical parabola and two parabolic reflectors were used at the Salisbury Plains British Post Office demonstrations of 1897.⁶⁵ The optical analogy does not *per se* preclude the notion of

developing a signalling technology.

In the light of Ramsay's view let us therefore reconsider the sources immediately available to Threlfall in 1890 that were referred to in his AAAS address to better understand the origins of the 'prophecy' and its' roots in the optical analogy. In 1888 Hertz had confirmed Maxwell's Theory that optical phenomenon were electromagnetic in character using a parabolic reflector to produce a parallel beam which Threlfall witnessed when he visited Karlsruhe in February 1889. Threlfall had met with Edison by April 1889 and had made the connection between 'etheric' and electric waves. Trouton, in conjunction with Fitzgerald, had repeated Hertz's optical experiments and went to publish in *Nature* in February and August 1889, including noting the future need for microwave photographs.⁶⁶ Lodge had also mentioned the use of photography in capturing lightning flashes earlier in July 1888 which may provide an alternative explanation for Threlfall's 1890 comment. Add to this the 1889 publications from Lodge and Howard, who had extended upon the work of Hertz by building large cylindrical pitch lenses to concentrate the electromagnetic radiation,⁶⁷ and from Dragoumis who noted the use of Geissler tubes for the detection of electrical oscillations whilst working in Lodge's Liverpool University laboratory.⁶⁸ In all, once we integrate these separate elements into a coherent whole we clearly see how Threlfall came to the conclusion he did about the possibility of developing a signalling technology using Hertzian waves starting with an optical premise.

WORK ON HERTZIAN WAVES IN AUSTRALIA

Soon after his return to Australia in late May 1889 Threlfall conducted a public lecture on 'The Present State of Applied Electrical Science' before the Royal Society of New South Wales on 24th June 1889. Based on his sabbatical tour, with a particular focus on the provision of domestic power supply, Threlfall gave an overview of what he had encountered in both Europe and the United States. The reporter covering the lecture indicated that Threlfall also conducted an "interesting experiment...by means of a complicated machine and two Leyden jars"⁶⁹, although the newspaper report assumes that the experiment related to the 'Thomson-Heuston' lightning arrestor and does not mention Hertzian or electric waves. Earlier that same day he had accepted the invitation to present what was to become the January 1890 AAAS paper.⁷⁰

A number of secondary sources suggest that Threlfall undertook experimental work at the University of Sydney on Hertzian waves in either 1888 or 1889.⁷¹ Whilst up to now there has been no direct evidence uncovered of these experiments taking place it is reasonable to assume that Threlfall demonstrated Hertzian waves to at least his students⁷², given both his first hand experience visiting Hertz and the capacity of the newly competed University workshop laboratories to manufacture the necessary experimental equipment required.

This view is reinforced by the detail provided in the AAAS January 1890 paper which not only demonstrates a strong grasp of contemporary research on electromagnetic waves but also shows a detailed knowledge of the con-

struction of test apparatus to detect these waves. In the paper Threlfall makes detailed references to the construction of test equipment and, whilst heavily dependent on the published work of Trouton⁷³, hints that his own experimental work may have taken place, as this discussion on resonator construction and operation demonstrates:

"In practice, the length of wire most appropriate to the resonator is found by experiment. The wire is bent into a circle and the ends brought close together by a fine screw attachment. ...The resonator for such waves as these was found to require two hundred and ten centimetres of No.17 wire when bent into a circle. Without going into the many very interesting questions as to the best relative positions of the planes of vibrator and resonator it will be sufficient to state that in one position of the resonator the most effective component is the electric, and in the perpendicular position the most effective component is the magnetic."⁷⁴

Thelfall's thinking on Hertzian waves was also influential in the wider Australian scientific community. William Bragg, then Professor of Physics at the University of Adelaide in South Australia and a future Nobel prize winner, was present at Threlfall's January 1890 AAAS address and soon began an extensive correspondence with Threlfall on all aspects of electromagnetism. Bragg had no exposure to electricity or magnetism during his undergraduate education at Cambridge and Threlfall's support at this time was critical to him developing any understanding of the field, including the application of Hertzian waves. Threlfall wrote to Bragg throughout 1890-91, although unfortunately the Threlfall side of the correspondence now ap-

pears lost.⁷⁵ However it is clear that Threlfall schooled Bragg in Maxwell's Theory and by August 1895 Bragg was giving his own public demonstrations of Hertz's experiments to an enthusiastic local audience.⁷⁶ Bragg also met a young Ernest Rutherford in Adelaide in 1895 on his way from New Zealand to Cambridge where Rutherford showed him a magnetic detector of his own design used to detect Hertzian waves. What makes the Bragg-Threlfall relationship all the more interesting is that Bragg himself went on to commence his own wireless telegraphy trials in South Australia on 13th May 1899.⁷⁷ Here we see evidence of Threlfall's academic and technical understanding leading to the practical application of Hertzian waves, this time through his colleague William Bragg.

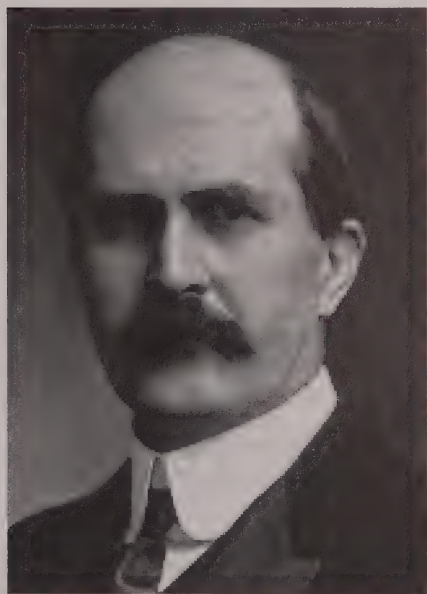


Figure 7 - William Bragg

THE DRAFTING OF THE AUSTRALIAN CONSTITUTION

The case for Threlfall's understanding of the technological implications following the discovery of Hertzian waves is further reinforced by a close examination of the development of what was to become the telecommunications power under the Australian Constitution during the course of the 1890s.

Prior to 1901 Australia was made up of six colonies that had been progressively founded by the British, commencing with the founding of a penal colony in Sydney on 26th January 1788.⁷⁸ In 1890 a Conference of seven colonies (including New Zealand) was held and a recommendation was made to hold a national Convention. This Convention opened in Sydney on 2nd March 1891.⁷⁹ The Convention established a drafting committee made up of Sir Samuel Griffith (Premier of the State of Queensland and prominent lawyer), Inglis Clark (State of Tasmania representative) and Charles Cameron Kingston (State of South Australia representative) who were responsible for the preparation of a draft Australian Constitution. A first draft was completed by Griffith on 25th March 1891.

The completion of the first printed draft of the 1891 Constitution coincided with an Easter break and Griffith decided to invite the drafting committee and selected others aboard the Queensland Government steamship *Lucinda* to continue the revision process at sea over the long Easter weekend. However those who boarded the *Lucinda* on Good Friday 27th March were not the original drafting committee. Clark was ill with influenza and was temporarily replaced by the New South Wales lawyer Edmund Barton, who went



Figure 8 - Sir Samuel Griffith

on to become the first Prime Minister of the Australian Federation on 1901. Amongst other guests was Bernhard Wise, a lawyer and former Attorney General of New South Wales, who was Richard Threlfall's brother-in-law.⁸⁰

Upon the return of the *Lucinda* the full Constitutional Committee began to review the proposed Constitutional clauses. On 30th March 1891 the Constitutional Committee commenced with the drafted phrase 'The establishment, maintenance, and regulation of, Postal and Telegraph Services' and next changed to 'Posts and Telegraphs & Telephones'. It is the next draft amendment that is of special interest because it contained the hand-written phrase 'including the [cancelled word-indecipherable] transmission of messag[es] by the Department of Posts & Telegraphs, & the transmission of information by any natural power'.⁸¹ Whilst the intended meaning of 'natural power' has not survived, we can reasonably speculate as to what

may have been intended. The science of physics was commonly referred to as 'natural philosophy' including classes taught by Threlfall⁸² at that time and 'natural power' could refer to electricity, including the use of electromagnetic waves in communication.

Whilst this phrase did not survive subsequent revisions of the 1891 draft Constitution it is important to examine whether Threlfall may have directly or indirectly influenced the thinking of those involved in the preparation of this particular draft wording. Sir Samuel Griffith was a member of the AAAS and it is plausible that he may have read a copy of Threlfall's January 1890 address. At the time of the 1891 Convention Griffith's diary records that he dined twice with Threlfall: on 6th March 'Dined with Prof. Threlfall and Wise' and again on 7th April Threlfall was a dinner guest aboard the *Lucinda*. Bernhard Wise's presence on the *Lucinda* during the Easter weekend may have introduced or reinforced his brother-in-law's ideas to the drafting committee at a critical point in their deliberations.

Griffith finally struck out the proposed change to leave the clause to simply read 'Post and Telegraphic Services' on 30th March 1891. The reasons for the change are not known but it has been suggested that the change was due to either the development of future technology being too theoretical or speculative, a failure to agree on an appropriate clause or that the Australian Constitutional fathers were simply prepared to allow the judiciary to deal with future technological changes.⁸³

Six years later there was a second Convention in Adelaide to resume the Constitutional work that had been abandoned during the intervening economic depression

of the early 1890s. This time Bernhard Wise was a full delegate to the Convention representing New South Wales when he proposed an amendment to the clause to read 'Postal, telegraph, telephone and other like services within and beyond the Commonwealth'. There was limited debate on the proposed amendment but the clause passed scrutiny with some small changes and became enshrined in the final draft of the Constitution which became law on 1st January 1901 upon the formation of the Australian Commonwealth. Today the clause still reads 'Postal, telegraphic, telephonic, and other like services' under Section 51 (v) of the Constitution.

The meaning of 'other like services' was perhaps now more obvious to those present at the 1897 Convention and resulted in less debate or concern amongst delegates. After all by then Marconi's work on wireless telegraphy was well reported in the Australian press and in August 1895 William Bragg had also conducted his public demonstrations of Hertzian waves in the city of Adelaide where the 1897

Convention was now being held. In the longer term the Constitutional provision 'other like services' had a life well beyond what even Threlfall may have envisaged, allowing the Australian Government to later regulate telecommunications including television.⁸⁴

BROADER COMMUNICATION OF THE 'PROPHECY'

Richard Threlfall was naturally proud of his 1890 AAAS paper and distributed copies of it widely to other academics. Upon publication of the paper Threlfall sent a copy to Heinrich Hertz.⁸⁵ Hertz responded on 28th December 1890 noting that "I heard many kind words about you" on his visit to the United Kingdom earlier that month to receive the Rumford Medal.⁸⁶ This comment is likely to have come directly from J.J. Thomson and took place when Hertz visited Cambridge in early December 1890.⁸⁷ In his correspondence Hertz acknowledged the relative isolation within which Threlfall worked in Australia when he said "I fear you must feel a little lonely in science in Australia, we feel rather a little pressed together here"⁸⁸ but made no detailed comments on the paper itself.

Threlfall also sent J.J. Thomson a copy of his January 1890 AAAS address. Thomson wrote to Threlfall on 14th August 1890 indicating that "I have written to Nature about your address they will be very glad to publish an abstract of it, so I have undertaken to indicate which parts can be left out."⁸⁹ However if an abstract was prepared it was never published – *Nature* only notes briefly that Threlfall presented an address as part of Section A of the 1890 AAAS.⁹⁰ It was Threlfall's own contact with Hertz that Thomson himself had relied upon in his initial invitation to Hertz to visit Cambridge



Figure 9-Bernhard Wise

in late 1890 when he said in correspondence "Though I have not the pleasure of your acquaintance I have heard a great deal from Mr Threlfall a friend of mine to whom you were very kind".⁹¹

J.J. Fahie's initial reference to Threlfall published in 1899 in *A History of Wireless Telegraphy 1838-1899*, after noting Sir William Crookes' 1892 comments on the future possibility of wireless telegraphy, reads in full "Prof. Lodge has since kindly pointed out to me that about 1890 Prof. R. Threlfall of Sydney, N.S. Wales, threw out a suggestion of the of the same kind at a meeting of the Australasian Association for the Advancement of Science."⁹² Lodge's recollection of Threlfall's paper is not surprising - Threlfall had sent him a personal copy which Lodge acknowledged in private correspondence dated September 1890.⁹³ Citing Threlfall

also suited Lodge's broader purposes by the late 1890s, by which time Lodge was in the process of showing that Marconi had not acted alone in the development of wireless telegraphy.⁹⁴

Threlfall did take an ongoing interest in the technology that was utilised in the development of wireless telegraphy. In 1897⁹⁵ he published on the conversion of electrical energy by dielectric hysteresis and was able to knowledgeably comment on condenser design at a Physical Society meeting in London in January 1898.⁹⁶ By 1903⁹⁷ he had presented to the Physical Society on a sensitive hot-wire voltmeter he had developed that was capable of measuring small high frequency currents (see Fig. 10). It should be noted however that its' use in radio reception and measurement was only one of many possible applications for

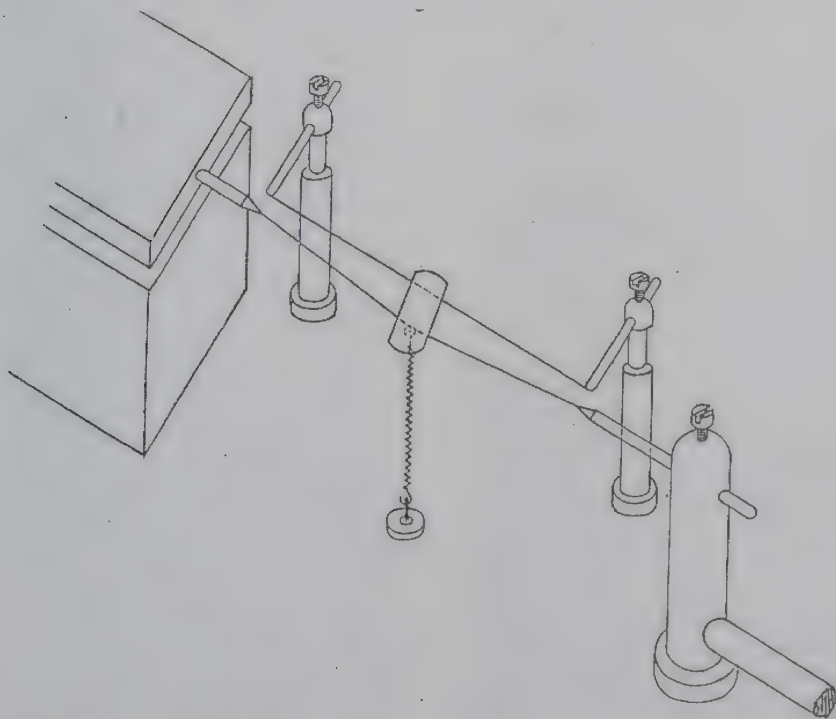


Figure 10 - Richard Threlfall's Hot-Wire Voltmeter

the instrument. Apart from these instances Threlfall did not pursue his ideas on signalling using Hertzian waves any further.

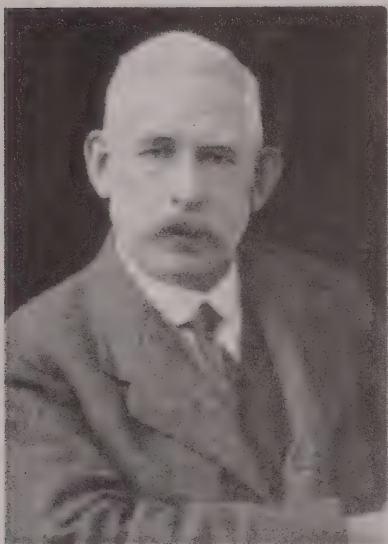


Fig. 11. Sir Richard Threlfall in later life.

CONCLUSION: RICHARD THRELFALL AND HERTZIAN WAVES

Richard Threlfall had the academic training, the experimental aptitude and the network of scientific contacts to be in a unique position to understand the implications of Hertz's discovery better than many of his peers in 1890. His early contact with Hertz cannot be underestimated and his close ongoing association with both J.J. Thomson and Oliver Lodge meant that he kept abreast of the most recent scientific developments in both the United Kingdom and Europe. He was well read and a deconstruction of the 1890 AAAS statement shows how clearly he linked a series of academic observations into the genesis of an idea about a future communications

system. In Australia he worked closely with William Bragg who went on to demonstrate the use of both Hertzian waves and wireless telegraphy. In addition both Threlfall and his brother-in-law Bernhard Wise appear to have influenced the drafting of the telecommunications power under the Australian Constitution at two critical points in its' development. In this context what Threlfall said in 1890 was more than a lucky guess and he had foreshadowed "the germ of a great future development."⁹⁸ Richard Threlfall was right and his views were to be vindicated within a decade with the development of wireless telegraphy. One is left to speculate what else might have been achieved if he had pursued his 'prophecy' through to fruition.

REFERENCE NOTES

1. See e.g. John Joseph Fahie **A History of Wireless Telegraphy 1838-1899** First Edition 1899 at p.197 footnote ; Lucienne Poincaré **The New Physics and its Evolution** New York D. Appleton and Company 1909 (authorised translation of the origin French version **La Physique Moderne , son Evolution** 1907) at p.222.
2. This career summary is taken from H.T. Tizard 'Sir Richard Threlfall G.B.E., F.R.S.' Obituary Notices Reprinted from **Journal of the Chemical Society** 1937 pp.186-195 , R.W. Home 'First Physicist of Australia: Richard Threlfall at the University of Sydney, 1886-1898' **Historical Records of Australian Science** Volume 6(3) December 1986 at pp.333-357.
3. J.J. Thomson 'Richard Threlfall Obituary' **Nature** Volume 130 13th August 1932 at pp.228-230.
4. Resumé of Richard Threlfall supporting application for the position of the Professor of Physics University of Sydney **Threlfall Papers** University of Sydney

- Archives P28/Series 5.
5. J.J. Thomson **Recollections and Reflections** London 1936 at p.118.
 6. Dong-Won Kim 'J.J. Thomson and the emergence of the Cavendish School, 1885-1900' **British Journal for the History of Science** Volume 28 1995 pp.191-226 at p.197.
 7. Thomson to Threlfall 13th April 1886 **Thomson Papers MS Add 7654 T7** Cambridge University Library.
 8. Richard Threlfall 'The New Physical Laboratory at the University of Sydney' **Building and Engineering Journal** Volume 2 1889 at pp.1-3.
 9. 10th August 1891 **Threlfall Papers** University of Sydney Archives P28/Series 4, Volumes 1 & 2 **Threlfall Papers Record Group 28** University of Sydney Archives.
 10. Richard Threlfall **On Laboratory Arts** Macmillan London 1898. On J.J. Thomson's support for publication see **Thomson Papers MS Add 7654 T35** (13th September 1895) , **T36** (17th April 1896) Cambridge University Library.
 11. Richard Threlfall and J.F. Adair 'On the Velocity of Transmission through Sea-Water of Disturbances of Large Amplitude caused by Explosions' **Proceedings of the Royal Society of London** Volume 46 1889 at pp.496-541.
 12. Richard Threlfall and J.A. Pollock 'On a Quartz Thread Gravity Balance' **Philosophical Transactions of the Royal Society of London A** Volume 193 1899 at pp.215-258.
 13. Richard Threlfall and J.H.D. Brearley 'Researches on the Electrical Properties of Pure Substances-No.1 The Electrical Properties of Pure Sulphur' **Philosophical Transactions of the Royal Society of London A** Volume 187 1896 at pp.57-150.
 14. Tizard **op. cit** at p.186.
 15. Richard Threlfall 'The Present State of Electrical Knowledge' Presidential Address in Section A (Astronomy, Mathematics, Physics and Mechanics) **Report of the Australian Association for the Advancement of Science**, January 1890 pp.27-54 at pp.45-46.
 16. Cited in Charles Susskind 'Hertz and the Technological Significance of Electromagnetic Waves' **Isis** Volume 56 (3) 1965 pp.342 - 345 at p.343.
 17. See e.g. Charles Susskind **Popov and the Beginnings of Radiotelegraphy** San Francisco Press 1962.
 18. **The Electrician** Volume 26 March 1891 at pp.685-686.
 19. William Crookes 'Some Possibilities of Electricity' **Fortnightly Review** Volume 51 1892 at pp.173-181. See also Charles Susskind 'The Early History of Electronics. III Prehistory of Radiotelegraphy' **IEEE Spectrum** April 1969 pp.69 - 74 at pp.69-70.
 20. Fahie **op. cit.** at p.197n.
 21. Poincaré **op. cit.** at p.222.
 22. See e.g. Tizard **op. cit.** at pp.191-192 ; Richard Evelyn Threlfall **The Story of 100 Years of Phosphorous Making 1851-1951** Oldbury England 1951 at p.135.
 23. Charles Susskind published a series of six articles on the early history of electronics between August 1968 and September 1970 in the **IEEE Spectrum**. Complete references are Charles Susskind 'The Early History of Electronics I. Electromagnetics before Hertz' **IEEE Spectrum** Volume 5 August 1968 at pp.90-98; 'The Early History of Electronics II. The Experiments of Hertz' **IEEE Spectrum** Volume 5 December 1968 at pp.57-60 ; 'The Early History of Electronics III. Prehistory of Radiotelegraphy' **IEEE Spectrum** Volume 6 April 1969 at pp.69-74 ; 'The Early History of Electronics IV. First Radiotelegraphy Experiments' **IEEE Spectrum** Volume 6 August 1969 at pp.66-70 ; 'The Early History of Electronics V. Commercial Beginnings' **IEEE Spectrum** Volume 7 April 1970

- at pp.78-83 ; 'The Early History of Electronics VI. Discovery of the Electron' **IEEE Spectrum** Volume 7 September 1970 at pp76-84. The third article in the series covers Richard Threlfall at p.69.
24. See e.g. Sungook Hong **Wireless from Marconi's Black Box to the Audion** The MIT Press 2001 at pp.8-9, 22; Tapan K. Sarkar, Robert J. Mailloux, Arthur A. Oliner, Magdalena Salazar-Palma and Dipak L. Sengupta (eds) **The History of Wireless** John Wiley and Son 2006 at pp.84, 264.
25. Thomson to Threlfall 3rd October 1888 **Thomson Papers MS Add 7654 T23** Cambridge University Library.
26. On the Bath meeting of the British Association in September 1888 and its implications for the promotion of Hertz's discovery see Bruce J. Hunt **The Maxwellians** Cornell University Press 1991 at pp.152-174.
27. Richard Threlfall 5th December 1888 leaving general instructions for the operation the Physical School "during my absence in Europe and America." **Threlfall Papers** University of Sydney Archives P.28/ Series 4.
28. Resumé of Richard Threlfall supporting application for the position of the Professor of Physics University of Sydney **Threlfall Papers** University of Sydney Archives P28/ Series 5.
29. Threlfall to Rayleigh 6th February 1889 cited in Home **op. cit.** at p.349 footnote 152.
30. Richard Threlfall 'Anniversary Address by the President Richard Threlfall M. A. Professor of Physics in the University of Sydney' Royal Society of New South Wales Sydney 1st May 1895 at p.12.
31. J.G. O'Hara and W. Pricha **Hertz and the Maxwellians : A Study and Documentation of the Discovery of Electromagnetic Wave Radiation, 1873-1894** Peter Peregrinus Ltd 1987 at pp.109-119.
32. On the dating of Hertz's experimental equipment see John H. Bryant 'Heinrich Hertz's Experiments and Experimental Apparatus: His Discovery of Radio Waves and His Delineation of their Properties' in D. Baird et. al (eds) **Heinrich Hertz :Classical Physicist, Modern Philosopher** Kluwer Academic Publishers Great Britain 1998 pp.39-58.
33. Hugh G.J. Aitken **Syntony and Spark – The Origins of Radio** John Wiley & Sons 1976 at p.74.
34. Adopted from Bryant's description **op. cit.** at p.45.
35. **Ibid** at p.46
36. Johanna Hertz (ed) **Heinrich Hertz: Memoirs, Letters, Diaries** (2nd enlarged edn) prepared by Mathilde Hertz and Charles Susskind, Translated by Lisa Brinner, Mathilde Hertz and Charles Susskind San Francisco Press 1977 at pp.279-281.
37. Hertz to Thelfall 27th February 1889 **Threlfall Papers** University of Sydney Archives.
38. Johanna Hertz **op. cit.** at p.283.
39. Threlfall to Hertz 9th March 1889 **HS 3084** Deutsches Museum Archiv.
40. This was suggested by Professor Rod Home University of Melbourne Australia in correspondence to the present writer dated 1st July 2009.
41. Hertz to Thelfall 27th February 1889 **Threlfall Papers** University of Sydney Archives.
42. Threlfall to Hertz 17th November 1890 **HS 3083** Deutsches Museum Archiv ; Hertz to Threlfall 28th December 1890 **Threlfall Papers** University of Sydney Archives. **Nature** Volume 42 23rd October 1890 at p.632 notes that Threlfall presented an enlargement of a photographic negative of Fresnel's interference bands used for teaching to the Royal Society of New South Wales on 3rd September 1890 in Sydney.
43. Bryant **op. cit.** at pp. 43-45.
44. Threlfall to Hertz 9th March 1889 **HS 3084** Deutsches Museum Archiv.
45. Threlfall to Hertz 17th November 1890 **HS 3083** Deutsches Museum

- Archiv.
46. Hertz to Threlfall 28th December 1890 **Threlfall Papers** University of Sydney Archives.
 47. Lodge to Threlfall 8th June 1888 **Threlfall Papers** University of Sydney Archives ,
 - Sydney Morning Herald** 18th August 1888 at p.7 , **Sydney Morning Herald** 22nd August 1888 at p.4.
 48. Professor Oliver Lodge 'The Discharge of a Leyden Jar' **Proceedings of the Royal Institution** 8th March 1889 pp.413-424 at p.420 ; Professor Oliver Lodge 'The Discharge of a Leyden Jar' **Nature** 14th March 1889 pp.471-474 at p.473.
 49. Threlfall to Hertz 9th March 1889 **HS 3084** Deutsches Museum Archiv.
 50. See Threlfall's comments on Lodge's discussion in 'Electrical Signalling without Connecting Wires' **The Electrical Engineer** Volume 21 4th February 1898 pp.147-149 at p.148.
 51. Home **op. cit.** at p.349.
 52. **Sydney Morning Herald** 27th May 1889 at p.6.
 53. **Sydney Morning Herald** 25th June 1889 at p.5.
 54. Richard Threlfall to J.J. Thomson from Hoffman House, Broadway, New York, 13th April 1889 cited in Lord Rayleigh **The Life of Sir J.J. Thomson** Dawsons of Pall Mall London 1969 at p.31.
 55. On Edison's 'etheric force' see Paul Israel **Edison A Life of Invention** John Wiley & Sons 1998 at pp.112-115.
 56. O. J. Lodge and J. L. Howard 'On the Concentration of Electric Radiation by Lenses' **Nature** Volume 40 23rd May 1889 at p.94.
 57. E.J. Dragoumis 'Note on the Use of Geissler's Tubes for Detecting Electric Oscillations' **Nature** Volume 39 4th April 1889 pp.548-549. See also Oliver Lodge's later comments 'Vacuum Tubes and Electrical Oscillations' **Nature** Volume 45 18th February 1892 at p.366.
 58. Oliver J. Lodge 'Photography of Lightning' Letters to the Editor **Nature** Volume 38 12th July 1888 at p.244.
 59. Fred T.Trouton 'Repetition of Hertz's Experiments, and Determination of the Direction of the Vibration of Light' **Nature** Volume 39 21st February 1889 at pp.391-393 ; Fred T. Trouton 'Experiments on Electromagnetic Radiation, including some on the Phase of Secondary Waves' **Nature** Volume 40 22nd August 1889 at pp.398-400.
 60. Trouton (1889b) **op. cit.** at p.400.
 61. See e.g. Home **op.cit.** footnote 89.
 62. Threlfall (1890) **op. cit.** at pp.44-46.
 63. Sungook Hong (2001) **op. cit.** at pp.2, 22.
 64. John F. Ramsay 'Microwave Antenna and Waveguide Techniques before 1900' **Proceedings of the IRE** February 1958 pp.405-415 at p.405.
 65. **Ibid.** at pp.406-407.
 66. Trouton (1889b) **op. cit.** at p.400 ; Ramsay **op. cit.** at p.414.
 67. Lodge and Howard **op. cit.**
 68. E.J. Dragoumis **op. cit.**
 69. **Sydney Morning Herald** 25th June 1889 at p.5.
 70. 24th June 1889 **Threlfall Papers** University of Sydney Archives P28/Series 4, **Sydney Morning Herald** 13th July 1889 at p.5.
 71. See e.g. John F. Ross **A History of Radio in South Australia 1897-1977** John F. Ross (Publisher) 1978 at p.13 ; Jan Todd **Colonial Technology Science and the Transfer of Innovation to Australia** Cambridge University Press 1995 at p.239.
 72. Professor Rod Home University of Melbourne Australia in correspondence to the present writer dated 1st July 2009.
 73. Trouton (1889a) **op. cit.** at p.391.
 74. Threlfall (1890) **op. cit.** at p.45.
 75. On Bragg's academic isolation see R.W. Home 'The Problem of Intellectual Isolation in Scientific Life : W.H. Bragg and the Australian Scientific Community, 1886-1909' **Historical Records**

- of **Australian Science** Volume 6 (1) 1984 pp.19-30. On Bragg's relationship with Threlfall see John Jenkin **William and Lawrence Bragg, father and son** Oxford University Press 2008 at pp.134-135.
76. **Ibid.** at p.153.
77. M.J. Gooley **A Report on Early Wireless Telegraphy in South Australia** Postmaster-General's Department Adelaide 1964.
78. For a history of penal settlement in Australia see e.g. Robert Hughes **The Fatal Shore A History of Transportation of Convicts to Australia 1787-1868** Pan Books Ltd 1988.
79. On the development of the Australian Constitution see J.A. La Nauze **The Making of the Australian Constitution** Melbourne University Press 1972; R.D. Lumb and K. W. Ryan **The Constitution of the Commonwealth of Australia** Butterworths 1977 at pp.1-6.
80. Bernhard Ringrose Wise **The Making of the Australian Commonwealth 1889-1900** Longmans, Green, and Co. London 1913 at p.126.
81. For a discussion of the successive drafting changes see J.A. La Nauze "Other Like Services": Physics and the Australian Constitution' **Records of the Australian Academy of Sciences** Volume 1 (3) 1968 at pp.36-44 , Geraldine Chin 'Technological Change and the Australian Constitution' **Melbourne University Law Review** Volume 24 (3) 2000 pp. 609-644 at p.610.
82. Natural Philosophy classes were still run at the University of Sydney by Threlfall himself at this time: see 8th June 1891 **Threlfall Papers** University of Sydney Archives P28/Series 4.
83. Chin **op. cit.** at pp.610-612.
84. **Ibid**
85. Threlfall to Hertz 17th November 1890 **HS 3083** Deutsches Museum Archiv.
86. Hertz to Threlfall 28th December 1890 **Threlfall Papers** University of Sydney Archives
87. O'Hara and Pricha **op. cit.** at p.112.
88. Hertz to Threlfall 28th December 1890 **Threlfall Papers** University of Sydney Archives
89. Thomson to Threlfall 14th August 1890 **Thomson Papers MS Add 7654 T25** Cambridge University Library.
90. **Nature** Volume 41 13th March 1890 at pp.441-443.
91. J.J. Thomson to Heinrich Hertz 19th November 1890 **HS 3080** Deutsches Museum Archiv, which is also cited in O'Hara and Pricha **op. cit.** at p.112.
92. Fahie **op. cit.** at p.197 footnote.
93. Lodge to Threlfall September 1890 **Threlfall Papers** University of Sydney Archives
94. Lodge (ca. 1900) **op. cit.**
95. Richard Threlfall 'On the Conversion of Electrical Energy in Dielectrics' **Physical Review** 1897 Volume IV at p.457 and Volume V at p.21; see also J.A. Fleming **The Principles of Electric Wave Telegraphy** Longmans, Green & Co. 1906 at pp.138-141.
96. Lodge (1898) **op. cit.**
97. Richard Threlfall 'On a New form of Sensitive Hot-Wire Voltmeter' **Philosophical Magazine** Series 6, Volume 7, 1904 at pp.371-376; see also V.J. Phillips **Early Radio Wave Detectors** Peter Peregrinus Ltd 1980 at pp.157-158.
98. Threlfall (1890) **op. cit.** at p.46.

ACKNOWLEDGEMENTS

Graeme would like to acknowledge the contribution of Emeritus Professor Rod Home of the University of Melbourne who reviewed a draft of this paper and made many helpful comments based on his extensive knowledge of Richard Threlfall. Dr John Jenkin of La Trobe University in Melbourne also assisted in providing advice on William Bragg's career in Australia.

PHOTO CREDITS

Figure 1 - Richard Threlfall in 1882 from H.T. Tizard 'Sir Richard Threlfall G.B.E., F.R.S.' Obituary Notices Reprinted from **Journal of the Chemical Society** 1937 pp.186-195.

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Figure 4 - Heinrich Hertz from www.nrao.edu/whatisra/hist_prehist.shtml (downloaded 3rd May 2010).

Figure 5 - Hertz's Laboratory from see John H. Bryant 'Heinrich Hertz's Experiments and Experimental Apparatus: His Discovery of Radio Waves and His Delineation of their Properties' in D. Baird et. al (eds) **Heinrich Hertz :Classical Physicist, Modern Philosopher** Kluwer Academic Publishers Great Britain 1998 pp.39-58.

Figure 6 - Oliver Lodge from www.unice.fr/.../Phoenix/photo/Oliver_Lodge.jpg (downloaded 3rd May 2010).

Figure 7 - William Bragg from http://nobelprize.org/.../laureates/1915/wh_bragg.jpg (downloaded 3rd May 2010).

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Figure 9 - Bernhard Wise from www.adbonline.anu.edu.au/biogs/A120614b.htm (downloaded 3rd May 2010).

Figure 10 - Threlfall's Hotwire Voltmeter from Richard Threlfall 'On a New form of Sensitive Hot-Wire Voltmeter' **Philosophical Magazine** Series 6, Volume 7, 1904 at pp.371-376 at p.372.

Figure 11 - Richard Threlfall in later life from H.T. Tizard 'Sir Richard Threlfall G.B.E., F.R.S.' Obituary Notices Reprinted from **Journal of the Chemical Society** 1937 pp.186-195.

ABOUT THE AUTHOR

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Graeme has previously published in the *AWA Review* on three occasions. He is also a member of the Historical Radio Society of Australia and the British Vintage Wireless Society. In September 2010 Graeme will present a paper to the Historical Radio Society of Australia based on the life and work of John Graeme Balsillie, the subject of his first *AWA Review* article in 2000.

Graeme's wife Jo Earl once again assisted in copying the Figures into a JPEG format so they could be appropriately reproduced.



Graeme Bartram

AWA Review

Communications Related
U.S. Army Recruiting
Posters

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ABSTRACT

The upcoming book *The Art of War: An Illustrated History of American Military Communication Posters* describes the history of communications themes in American military posters. This article introduces the subject by focusing on U.S. Army and Air Force recruiting. The poster evolved as a printed medium during the same period as electronic communications came of age. First radio, then television, and now digital media have supplanted print in much of the advertising world. Even today, the poster's basic form survives; albeit in a different context, on the internet.

The poster was instrumental in appealing to the public, stimulating national unity and promoting military recruiting. Governments recognized that posters offered an essential means of communicating with the public in both World Wars I and II. The posters also demonstrate how government used media to teach the public about wartime policies.

Government posters instill patriotism, national confidence and attract citizens for service. They are simultaneously propaganda, artwork and advertising, and offer a window into the motives and appeals of the past.

Posters are designed to send a message. A successful poster should be capable of only one interpretation. Posters were accepted and understood by the public in a world that preceded radio, television and the internet. At a time when newspapers were still the privilege of a literate minority, posters delivered their messages to the masses. (Rickards, 1968).

Often using stark imagery, government posters appealed to people's conscience, their fears, and the ideals of freedom and democracy. Posters called upon every man, woman and child to make personal sacrifices for the national cause. Wartime posters were not just used for recruiting. Posters linked the home front with the military effort by boosting worker morale and encouraging productivity, advertising the sale of government bonds, highlighting rationing, and encouraging conservation and security. (Aulich, 2007)

The coordination and production of recruiting posters required considerable resources, and they were considered an integral part of wartime communications strategy. The government sought help from the nation's foremost artists and illustrators of the time. Norman Rockwell, Howard Chandler Christy, James Montgomery Flagg and Charles Dana Gibson are among the many who contributed their talents. The U.S. government established formal offices to organize the design, manufacture and distribution of posters on a grand scale in both World War I (Committee of Public Information) and World War II (Office of War Information). These offices also promoted the overall demand for posters by providing central clearinghouses for requests emanating from government and volunteer agencies.

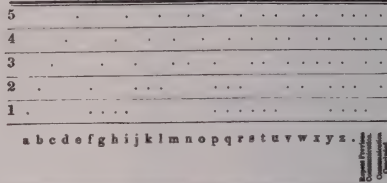
The scale of the U.S. national poster effort was tremendous. For example, during April 1918 in the midst of World War I, individual runs of approximately 9 million posters were produced and distributed just for the Third Liberty Loan. (Darracott, 1974) During World War II, 1.5 million copies of each major poster were printed, and 10,000 message cards were placed in subways, buses, trains and trams each month. (Bird, 1998) The reproduction of popular World War II recruiting images reached 40,000 to 50,000 posters each. Upwards of 60,000 to 80,000 window cards were also produced for the more popular images. (U.S. Naval Historical Center, 2008)

The first half of the 20th century brought tremendous changes to American society as electronic media were developed and adopted by American households. Even more apparent was the critical impact these technologies had on fighting and winning two world wars. Despite the necessity and urgency of military needs and the growing awareness of electronics by the public, there are relatively few posters specifically designed to recruit radio, wireless, telephone and other communication specialists into the service of their nation.

EARLY AMERICAN COMMUNICATIONS POSTERS

American posters trace their origins to early broadsides that were once printed to publicize announcements and declarations. Early broadsides were no more than large sheets of paper printed on one side. They were glued to a wall or sign post to inform the public of news and events of general interest. Many were given away, and others were produced to sell for profit as commemorative illustrations of notable events (Fig. 1).

ELECTRO-MAGNETIC TELEGRAPH!!



KEY TO AN ELECTRO-MAGNETIC TELEGRAPH ADAPTED FOR POPULAR ILLUSTRATION BY **ROBERT GRANT,** And NOW EXHIBITED at the Large Room, **MASONIC HALL.**

This Telegraph enhances the Electro-Magnetic combination first applied to Telegraphic communication by our illustrious countryman, PROFESSOR MORSE, and now in successful operation between Baltimore and Washington Cities.

This Telegraph differs from Professor Morse's only in the mechanical arrangement, whereby some facilities are obtained in the manipulation and in the rapidity of communication. It also requires no attendance at the working terminal, every operation being complete both in starting and stopping, and throwing off the written sheet, Professor Morse's, on the contrary, requires, at present, constant attendance, to start and stop the clock-work which carries the sheet over the stylus.

The principal distinction between this Telegraph and Professor Morse's, is the employing of five wires instead of one, making a difference in the nett expenses of construction equivalent to \$250 per mile in favor of Professor Morse's. It is, however, capable of writing ten words while that of Professor Morse writes one.

It is worked with keys, like the piano-forte, and can be manipulated with ease at the first sight, by the most delicate lady.

It is not liable to interruption from breaking one or more of the wires, as different combinations, with less mechanical facilities, can be adapted immediately on the same machine, with four, three, or two wires, until it resolves itself into Professor Morse's plan direct.

OPEN DAY AND EVENING.—FOR A SHORT TIME ONLY.

ADMITTANCE 12½ CTS.

EVERY EVENING the Room will be Brilliantly Illuminated by

THE DRUMMOND LIGHT!

ALSO, A SERIES OF BEAUTIFUL

DIORAMIC VIEWS!

Will be exhibited by the OXY-HYDROGEN CAMERASCOPE.

Convenient Seats for the Evening Exhibition, can be secured by attending early.

The Exhibition will open on Friday, August 2.

United States Job Printing Office, Ledger Building, Philadelphia.

Fig. 1. 1850. Not attributed. Courtesy of U.S. Library of Congress, Samuel F.B. Morse Papers. See Samuel Morse, 1850.

The first American broadsides to include communications themes advertised early telegraph companies. First demonstrated in 1844, Samuel Morse's electric telegraph was soon the subject of many imitations and competing claims. The earliest known American communications broadside presents Robert Grant's advertisement for his telegraph demonstrations at the Masonic Hall in Philadelphia. In



Fig. 2. 1858. H.H. Lloyd & Co. Wynkoop, Hallenbeck & Thomas, Printers. Version 1. Author's Collection.

the “Electro-Magnetic Telegraph”, circa 1850, Grant claimed his system was capable of sending at a rate ten times faster than Morse’s. This broadside was found in Samuel Morse’s papers at the Library of Congress. It was published by the United States Job Printing Office in Philadelphia.

The most widely celebrated

communications event of the 19th century was the linking of the United States and Great Britain through the world’s first trans-Atlantic telegraph cable. Many broadsides commemorated this event in 1858 and again in 1866 when the venture finally proved successful. In one example, H.H. Lloyd & Co. in New York published its 1858 “Telegraph

Chart". Printed by Wynkoop, Hal-lenbeck & Thomas, this broadside provides a detailed history of the telegraph industry up until the 1858 Atlantic Cable and explained the history of the magnetic telegraph, Atlantic Cable venture, the telegraph industry and submarine telegraphy (Fig. 2). Two other versions of this broadside are known to exist, with different images placed mid-ocean in the top map, and additional space provided for the messages exchanged between President James Buchanan and Queen Victoria. (Burns, 2009)

Newspapers and trade journals provided the most common form of illustrated advertising for telegraph equipment. Broad-sides were also used extensively. The American District Telegraph (ADT) published a colorful chromolithograph advertising its alarm systems in the 1880s. This advertisement was printed by Schmidt Label & Lithograph Co. It is a five part image showing telegraph messengers and a telegraph office in the center with illustrations around the margins of home security, fire response, doctor's calls, and messenger services (Fig. 3).

The telegraph and Atlantic Cable posters represent the first appearance of communications themes in American broadside and early poster production. The emergence of lithography and more advanced printing techniques eventually enabled their mass production, and historic events stimulated public demand for commemorative ephemera.

During and after the U.S. Civil War, the broadside's role in publicizing major events was supplanted by illustrated newspapers, including *Harper's Weekly* and *Leslie's Illustrated News*. Nevertheless, by the close of the 19th century, the broadside was still being

used as an inexpensive advertising medium. Even more dramatic, advances in color lithography, the influence of Art Nouveau styles, and developments in high speed printing enabled the mass production of posters. Cataclysmic events would soon lead governments to recognize and exploit posters as a straightforward means of communicating with their populations. Now, the poster could be applied not only in advertising, but as a vehicle for spreading propaganda in a world war. (Hutchison, 1968; Gallo, 1972)

PRE-WORLD WAR I U.S. ARMY POSTERS

U.S. Army recruiting posters trace their origins to the Revolutionary War period. Each colony sought volunteers and mustered local militias to help protect home and country from the invading British army. Paul Revere's widely disseminated engravings of the Boston Massacre and engravings by Amos Doolittle and Bernard Romans of the battles at Lexington, Concord and Bunker Hill helped inflame public opinion and stirred patriotic fervor. (Chambers, 2000)

Recruiting took on whole new meaning during the Civil War when both the Union and Confederacy mobilized huge numbers of men for military service. Many posters appealed to ethnic and national themes of unity. Most broadsides only contained text, although some included a simple picture such as a cavalryman or soldier, or an ethnic symbol such as an Irish harp for the Irish Brigade.

The Civil War was the first war where the rapid movements of large numbers of men over vast territories were controlled by the telegraph. The telegraph is often credited for its contributions to the



Fig. 3. Circa 1880. American District Telegraph. Schmidt Label & Lith. Co. Courtesy of the University of California Libraries, Bancroft Library, Collections of Framed Items California Lithographs (BANC PIC 1998.010:02-FR). See Museum, 2010.

Union's victory. Yet, neither the U.S. Military Telegraph, nor the U.S. Army Signal Corps conducted their own recruiting campaigns. Although both the Union and Confederacy relied on former civilian telegraph operators, neither side conducted recruiting campaigns that targeted individuals with these skills.

In fact, no examples have been found illustrating the U.S. Army's communications technology in any posters until 1910. The first and only pre-World War I U.S. Army recruiting posters illustrating communications technology were drawn by Michael P. Whelan (sometimes spelled "Whalen"). His series of posters "Men Wanted for the Army" featured landscapes with large canon, mounted soldiers, pressed uniforms and noble figures. One poster shows a panorama of a field telegraph operator and distant wig wag flags providing communications for coordinating artillery fire from a hillside. The bottom of the printed area had a location to hand stamp the address of the local recruiting station (Fig. 4.).

WORLD WAR I

The rapid, mass mobilization demanded in World War I led directly to the production of communication and technology based recruiting posters. Faced with the need to quickly mobilize thousands of men for rapid deployment to Europe, the U.S. focused on finding men who already possessed technical training.

The Army emphasized its educational offerings for the first time by listing its training programs and displaying photographs of their wartime applications of communications technology. This was a dramatic change in recruiting philosophy. The earliest posters in the war effort initially resembled the

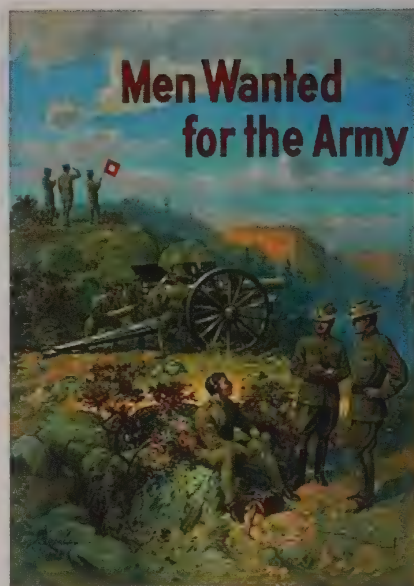


Fig. 4. 1910. Michael Whelan. U.S. Army. Author's Collection.

heavy text-laden announcements of the 19th century.

In the "Wanted-At Once" window cards, the Army advertised that it was looking for radio, telegraph, telephone operators and telephone linemen (Fig. 5). Enlistments in the Signal Corps extended for three years instead of the one year enlistments for the Quartermaster Corps and Medical Department. In the poster "Young Man! Do You Want To Better Yourself?" the Army advertised its Coast Artillery School (Fig. 6). This school, located in the historic Fort Monroe near Hampton Roads, Virginia, opened in 1907. It was the Army's premier training facility for artillery and anti-submarine mine defenses. (Big School, 1907) The poster offered a free education and career training in a number of areas including Telephone, Electrician, Cable Splicer and Radio Operator. The Army quickly moved

away from this poster style, favoring the impact of more dramatic images and catchy slogans.

H. Devitt Welsh introduced a new poster format made spe-

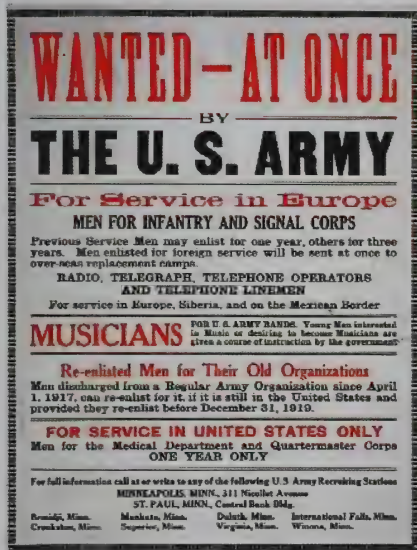


Fig. 5. 1917. U.S. Army. Courtesy of Minnesota Historical Society Collections (89734).

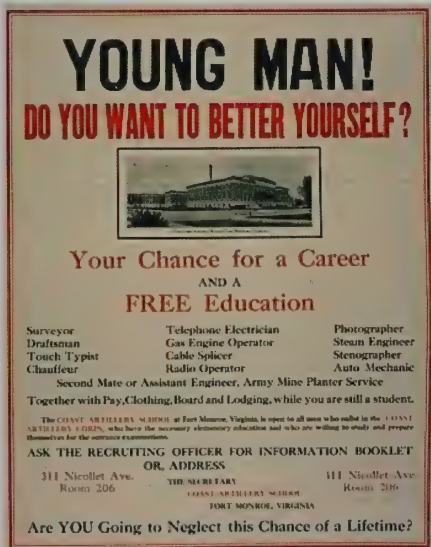


Fig. 6. 1917. U.S. Army. Courtesy of Minnesota Historical Society Collections (90820).

cifically for the U.S. Army Signal Corps in 1917-1918 in which the Army offered to train new recruits in the communication fields. "If You Are An Electrician Mechanic or A Telegraph Operator You Belong In The US Army Signal Corps" directly addresses the viewer and makes the pitch for both recruiting and training (Fig. 7).

Welsh's dramatic poster features an abstracted image of soldiers using wireless radio communication with the Army's new portable "wagon set" radio. Al-



Fig. 7. 1917-1918. H. Devitt Welsh. U.S. Army. Author's Collection.

though field wireless radio sets were becoming more portable, they were still bulky. The wagon set required 18 mounted men, the wagoner and engineer, who rode on the set, plus four mules to pull the wagon. Its 80 foot telescopic mast antenna helped give it a broadcast and reception range of up to 800 miles depending on the weather. (Drill Regulations, 1911; Radiotelegraphy, 1916)

Viewed by today's standards, this seems awkward, but these were the first radios used in warfare. The wagon set, and its companion, the mule pack set which required 10 mounted men and four pack mules, freed communications from the limitations of land line telegraphy and hand delivered messages. (Drill Regulations, 1911) The wireless radio was a major advance in communication and it had profound effects on the conduct of war.

Throughout the war, the Signal Corps also directed the Army's new aerial combat services. The poster "You Can Win A Preferred Position In The U.S. Army Signal Corps By Intensive Training" featured both of the Signal Corps' new technologies (Fig. 8). The poster showed a portable wagon wireless set and a biplane flying in the distance. The full height of the wireless wagon set's 80 foot antenna is shown along with nine of the 18 soldiers required to operate it. The focus of the poster's message on training highlights vocational skills available to new recruits. The underlying message was that the recruit would retain these skills after completing a tour of service in the Army.

Many private companies also advertised their contributions to the war effort. The Signal Corps' need for experienced radio and telegraph operators familiar with Morse code was featured by Victor Records in its advertisement "Special Victor Records Help Train Wireless Operators" (Fig. 9). Although the poster was issued on behalf of a private company to advertise its products, it is notable for providing a close-up view of the wireless wagon set. The operators are shown sending and receiving messages using a Marconi 106 wireless radio set made by the Mar-

coni Wireless Telegraph Company. The Marconi 106 radio was one of the first radios to see actual service in combat operations.

Railroad and other landline telegraph operators often found it challenging to switch from American Morse to the International Morse used in radio communications given the short time frame allowed for training. Fresh recruits with no prior experience had great difficulty learning to communicate fast enough. Classrooms were hastily established at 45 American colleges and universities to process up to 4,000 trainees per month through new 13 week training programs. Of the 625 hours of initial training, 82 hours directly involved telegraphy and signaling or wireless radio applications. Instructors typically used buzzers, headphones and telegraph practice keys to enable students to reach minimum proficiencies of 20 words per minute for both telegraph and radio communication. (Report, 1919; Bart, 2006)

The poster advertises "Victor Records" produced by Victor Talking Machine Company. The Marconi Wireless Telegraph Company and Victor Talking Machine Record Company jointly developed this set of 12 - 78 RPM phonograph training records. The records contained pre-recorded exercises for practicing American Morse and International Code. (Chadwick, 1918) Though primarily intended for commercial wireless training, the records provided practice for both amateur radio operators and professional land line telegraphers. The records became available to the public as early as 1919 and were sold as the "Marconi Victor Course in Wireless Telegraphy" after 1922. These are the first recordings ever issued to teach telegraphy. (Pierpont, 2002; Bart, 2006).

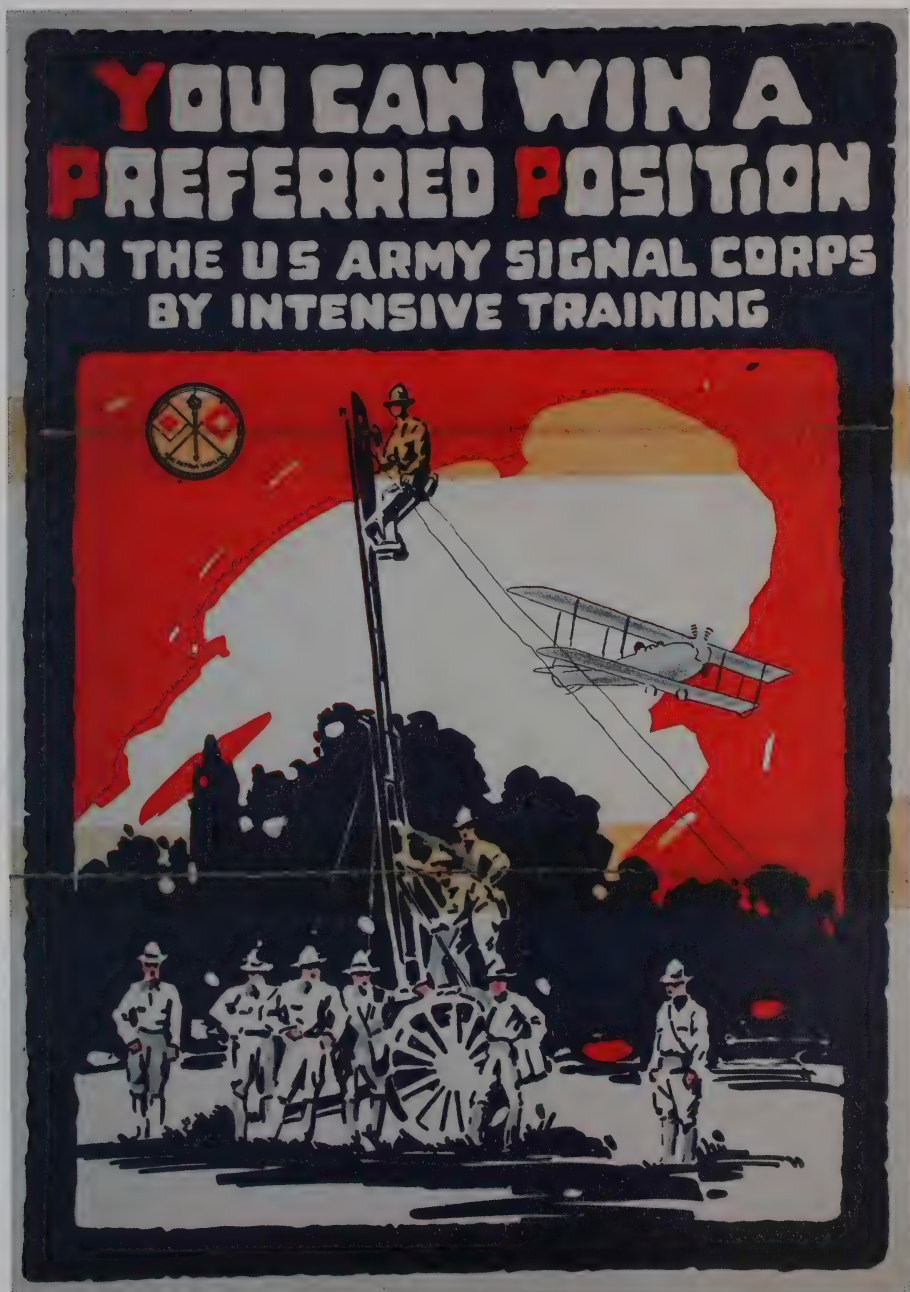


Fig. 8. WWI. U.S. Army Signal Corps. Courtesy of James and Felicia Kreuzer.

In 1919, J. McGibbon Brown put together a full listing of Signal Corps educational opportunities and produced his “Enlist In The Signal Corps” poster (Fig. 10). All

but three of the options available for new recruits involved some type of communications training. Carrier pigeons still remained a viable frontline method for send-



Fig. 9. WWI. Victor Talking Machine Company. Courtesy of James and Felicia Kreuzer.

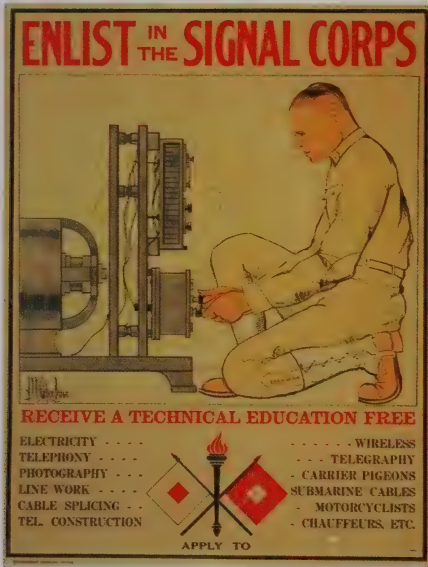


Fig. 10. 1919. J. McGibbon Brown. U.S. Army. Author's Collection.

ing messages; and these soldiers had separate Signal Corps training requirements to learn about handling the birds and using ciphered messages. The remaining eight programs all involved training in electrical technologies. Despite the arrival of telegraphy, the telephone and the phonograph, the wonders of instant communication were still somewhat new to the large population of rural America.

J. McGibbon Brown's poster is notable for its use of stylized line drawing. Here, the soldier tunes a large spark transmitter. These early radios generated a radio frequency when an electric charge jumped across an open gap between electrodes which operated at extremely high voltage. The charged spark was switched on and off by using a telegraph key. They were used in huge broadcasting stations operated by the military for international radio transmission. (Robison, 1919; Report, 1919) Voice communication would not become established until the

mid-1920s and would not become widely used by the military until the mid-1930s. (Raines, 1996)

Harry S. Mueller's 1919 "The Signal Corps Trains Men For Telegraph Telephone Radio" took a more direct approach (Fig. 11). His poster included five black and white photographs showing the Signal Corps in action. The images showed wartime photography, a class in cable splicing, a signal corps telephone office, storage batteries, and a radio instruction school. A world map dominates the background with dramatic lightning bolts emanating from Washington, D.C. to Nome, Alaska; Paris; Panama; the Hawaiian Islands and the Philippine Islands. Mueller's image conveyed that the Signal Corps was the nerve center of the Army, binding it together and connecting important U.S. military locations around the world. Service was rendered under difficult circumstances, and radio was prominently featured.

Charles Livingston Bull focused on the Signal Corps' Army Air Service with his image "Join The Army Air Service" (Fig.12). This poster showed the American Bald Eagle defeating the Prussian Eagle in air combat. In the end, the Air Service's contributions were limited by the short duration of the war and the longer lead times necessary to recruit, train and equip its personnel. Nevertheless, the Air Service experienced remarkable growth from an initial tally of only 1,178 officers, men and trainees at the beginning of the war. By the Armistice, over 4,000 had graduated from training schools, over 1,200 pilots and observers were serving on the front line, and 23,000 men were accepted into training courses. Cadet schools had graduated over 10,000 students. Radios had been installed



Fig. 11. 1919. Harry S. Mueller. U.S. Army Signal Corps. Author's Collection.

on nearly 1,700 airplanes. (Report, 1919; Boyne, 2009)

The Signal Corps had expanded dramatically during America's short involvement in World War

I. Total strength grew from 55 officers and 1,570 men on April 6, 1917 to 2,712 officers and 53,277 men at the close of the war. (Report, 1919) The poster recruiting campaigns

had played an important role in attracting and educating the public about the opportunity to learn military communications.

THE INTERWAR YEARS

After the war, the Signal Corps shrank rapidly to levels under 4,000 soldiers, and it was almost eliminated in the peacetime Army. Somewhat ignored, and short of materials and men throughout the depression years, its recruiting suffered badly. World War II would reestablish the need for vital wartime communications. (Signal Corps (a), 1956; Raines, 1996)

Immediately prior to World War II, several recruiting posters showed the range of careers available in the Army. The "Army Officers Insignia of Rank" showed Signal Corps insignia alongside the insignia for field and coast artillery, infantry, air corps, cavalry, and engineers (Fig. 13). In 1942, the U.S.

Army Recruiting Publicity Bureau reissued several variations of these posters in both poster format and as double sided folded brochures suitable for mailing. These poster-brochures educated the reader and raised awareness of opportunities in the Army.

WORLD WAR II

America's entry into the war was sudden and unexpected following the Japanese bombing of Pearl Harbor. Although the Roosevelt Administration had been building up resources for the country's eventual participation in the conflict, the attack still came as a surprise. The U.S. Army quickly sought men for all service areas.

The 1942 poster "Radiogram" issued by the U.S. Army Recruiting Publicity Bureau appealed to men of 18 and 19 by offering them new enlistment privileges (Fig. 14). Men were instructed to apply at



Fig. 12. 1918. Charles Livingston Bull. U.S. Army Signal Corps. Alpha Lithograph Company, Inc., NY. Courtesy of Minnesota Historical Society Collections (90006).



Fig. 13. 1941. U.S. Army Recruiting Service. Courtesy of AskArt.Com (14397459A).

U.S. Army Communication Posters

U.S. Army Recruiting and Induction Stations for a number of services including the Signal Corps.

“Action” shows the Airborne Infantry running out of a military airplane with rifles and weapons



RADIOGRAM

TO MEN OF 18 AND 19 . . .
NEW ENLISTMENT PRIVILEGES

... IN

- MEDICAL DEPARTMENT
- ORDNANCE DEPARTMENT
- QUARTERMASTER CORPS
- CORPS of MILITARY POLICE
- CHEMICAL WARFARE SERVICE
- SIGNAL CORPS • AIR FORCES
- ARMORED FORCE • CAVALRY
- INFANTRY • FIELD ARTILLERY
- COAST ARTILLERY CORPS
(Antiaircraft • Harbor Defense)
- CORPS of ENGINEERS

APPLY NOW AT ANY **U.S. ARMY** RECRUITING and INDUCTION STATION

Fig. 14. 1942. U.S. Army Recruiting Publicity Bureau. Courtesy of George C. Marshall Foundation Research Library Poster Collection (577).

ready for combat (Fig. 15). This poster invites men 18-19 years of age to choose their combat branch, listing eight options including the Signal Corps.

The Army also hoped to interest high school graduates in its new "Aviation Cadet Training" Program (see below; Fig. 16). This poster indicated that men of 17 years but less than 18 years of age could voluntarily enlist in the Air Corps Enlisted Reserve for future training as Aviation Cadets. Those between 18-26 years of age could become bombardiers, navigators and pilots in the Army Air Forces.

Some posters featured the Army's new mobile radio communications. In 1943, "Think Fast Soldier" showed a Signal Corpsman using an AM short-range two-way radio (Fig. 17). The model is not identified, but the soldier is talking into a hand-held microphone and he is wearing a headset under his helmet. These types of radios were primarily used in jeeps and tanks, and became the backbone of armored and artillery divisions. Galvin Manufacturing, Inc. (later renamed Motorola, Inc.) produced a number of AM, and later FM, mobile sets for the military. In total, Galvin manufactured over 96,000 of these models. (Motorola, 1994) The poster notes that communication by radio takes place at 186,000 miles per second, and implies that radio is vastly superior to the much slower telegraph and telephone land based systems.

The 1942 a new poster-brochure "Do You Know" informed the viewer about the range of new and amazing technologies used by the Signal Corps to link infantry, artillery, armor and airborne operations (Fig. 18). The Signal Corps is portrayed as the communications center of the Army. Options for enlistment are spelled

out. Photographs show radio operations under a variety of front line settings as well as photographs of soldiers in training. These new poster-brochures were designed to fold down for mailing. When opened, one side had a main panel that served as a poster for display.

"Now Is The Time", another 1942 poster by the U.S. Army Recruiting Publicity Bureau, advertised a list of the available service specialties (Fig. 19). As the noble civilian looks on and ponders his decision, infantry are seen marching boldly to the defense of the nation. A radio operator is shown prominently in the center of the image.

The U.S. Army Training Institute returned to educational offerings by comparing the "before" and "after" affects of training in "The Educational Program of the United States Army" (Fig. 20). It spelled out the advantages of becoming a better soldier: attaining promotion, preparing for officer training, continuing education and qualifying for a better job. Training in fields such as electricity, radio and radio code could be taken prior to enlistment at more than 77 universities offering over 700 courses. The goal was to train youth prior to reaching enlistment age so they could be prepared and ready for their future jobs in the Army upon induction.

World War II witnessed the emergence of the U.S. Army Air Corps which, in 1947, was renamed the U.S. Air Force. The Air Force sought to rapidly increase the number of pilots by recruiting students as they graduated from high school. In June 1941, the Army Aviation Cadet Act created the grade of "aviation cadet" with the immediate goal of recruiting and training over 85,000 new pilots. The program was extremely



Fig. 15. 1942. United States Army, Recruiting Publicity Bureau. Courtesy of Northwestern University Library, World War II Poster Collections (ww0207-08).



Fig. 16. WWII. U.S. Army Recruiting Publicity Bureau. Courtesy of Minnesota Historical Society Collections (91065).

successful. Along with the almost 200,000 pilots, the aviation cadet program graduated about 100,000 navigators, bombardiers, and observers. (Boyne, 2009)

Despite the tremendous need for radio operators to man the aircraft and ground operations, virtually no separate recruiting was done by the Air Corps/Air Forces to specifically attract trained civilian communications personnel. The poster-brochure “Here’s Your Opportunity If You Work With Tools” highlighted many jobs including Aircraft Radio Mechanics and Aircraft Radio Operators (Fig. 21). The opportunity to fly in a B-24 Liberator was prominently featured in the photograph. A similar approach was used in “A New Opportunity For Experienced Mechanics and Radiomen”.

Of all the posters, Jes Wilhelm Schlaikjer set the standard for il-

lustrating the Signal Corps’ noble mission in battle with his painting “Where Skill And Courage Count” (Fig. 22). This poster portrayed stability, firm resolve and the necessity of communication under the harshest of battlefield conditions. Here, the Corpsman, or artillery observer, maintains telephone communications while all around him the battle rages. This image was also issued with the title “The Message Must Go Through”. It was used both in recruiting and as a morale propaganda poster to stimulate wartime production. The image was reproduced in window cards, small poster sizes and with quarter-sheet promotional text on the bottom. The basic design was also used for other services including the engineers and military police.

A much simpler version of the Schlaikjer design is seen in the

THINK FAST SOLDIER



GET THE MESSAGE THROUGH

Fig. 17. 1943. First Service Command, Signal Corps Training Section. Courtesy of Motorola Corporation in Motorola, 1994.



Fig. 18. 1942. Main Panel For "Do You Know" Poster-Brochure Designed For Mailing. U.S. Army Recruiting Publicity Bureau. Courtesy of Northwestern University Library, World War II Poster Collections (ww0870-16).

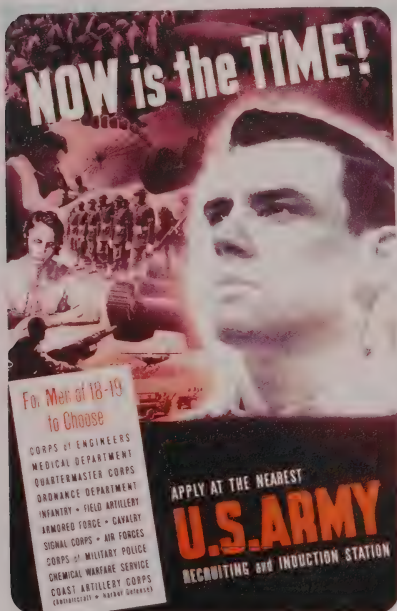


Fig. 19. 1942. U.S. Army Recruiting Publicity Bureau. Courtesy of the University of North Texas Digital Library (WW2 RPB 2).

“Responsibility and Character” poster produced by Joe Zutz (Fig. 23). Here, the solder is seen using an SCR 536/BC-611 hand held radio, the first ‘walkie-talkie’. The ‘walkie-talkie’ was developed and first produced by Galvin Manufacturing (Motorola). It represented a major leap in portable two-way radios and was the smallest field unit of all Signal Corps radios produced in the war. It could operate by battery on any one of 50 channels for up to 15 hours. It was widely used and had a range up to three miles. By the end of the war, Motorola had produced more than 100,000 walkie-talkie type radio units. (Motorola, 1994).

The U.S. Army Signal Corps had grown significantly during the war. By 1945, the U.S. Army Signal Corps achieved aggregate strength of 352,309. The Signal Corp's peak civilian strength during the war

The Educational Program of the United States Army

BEFORE YOU ENTER THE SERVICE

- Take specialized school and college courses that prepare you for army life
- Make yourself a better soldier; improve your chances for a specialist job and promotion
- Enroll in official pre-induction courses approved by the War Department

New available: Electricity, Shopwork, Machines, Radio, Automotive Mechanics

Ready soon: Clerical, Radio Code

Watch for: Announcement of New Courses

- You will receive a certificate of proficiency upon completion of the authorized Pre-Induction training courses. Give this certificate to the Army personnel interviewer after you are inducted into military service

PRE-INDUCTION TRAINING SECTION
 CIVILIAN PERSONNEL DIVISION OF HEADQUARTERS
 SERVICES OF SUPPLY, WAR DEPARTMENT
In cooperation with the United States Office of Education

AFTER YOU ENTER THE SERVICE

- Enroll with the Army Institute
(after you have completed your basic training)
- The Army Institute will enable you to
 - ... be a better soldier
 - ... fit yourself for promotion
 - ... prepare for officers training
 - ... continue your education
 - ... qualify for a better job
- Prepare now to take advantage of this opportunity. See your counselor, dean, advisor, or other guidance officer about courses which you may take while in the Service. He has a copy of the Army Institute Catalog
- More than 700 high school and college courses are available by correspondence. 77 universities are cooperating
- After you are inducted see your Special Service Officer, Librarian, or Chaplain for full details of enrollment

ARMY INSTITUTE
 SPECIAL SERVICE DIVISION SERVICES OF SUPPLY
 MADISON, WISCONSIN

Fig. 20. 1943. U.S. Army Institute. Courtesy of Minnesota Historical Society Collections (90754).

was 61,628. It was now over 80 times larger than its 1940 total of 3,935 enlisted men and officers. Almost 13% of all combat troops were involved in communications and approximately 4% of the total force was comprised of Signal Corps personnel. (Signal Corps (c), 1966; Raines, 1996).

POST-WORLD WAR II

After the war, the Signal Corps demobilized and maintained a peacetime strength of 50,000; rising briefly during the Korean War to 90,000 enlisted men and officers, and decreasing again to 50,000 thereafter. (Raines, 1996)

The nature of recruiting posters changed quickly after the war. Patriotism was no longer the overwhelming message. The Army shifted toward career-education topics, and perceived social status, travel or other non-financial motives to attract recruits. (Padilla,

2001) A subsequent study further evaluated U.S. Army posters and advertising from 1954-1990. Even with the tumult of the 1960s and 1970s and protests against the draft during the Viet Nam War, occupational themes dominated the recruiting messages. Emphasis was placed on staffing high tech positions to combat the threat of missiles and bombers during the Cold War, and reflected an overall shift away from group patriotism and solidarity, toward a civilian influenced model where soldiers were viewed primarily as employees filling staff positions. (Padilla, 2001)

Between World War II and the year 2001, only a single Army recruiting poster appeared with a communications theme. "Serve as a Soldier Specialist", which appeared during the Vietnam conflict, showed Signal Corps radio operator/mechanic working on



Fig. 21. WWII. Panel from “If You Work With Tools” Poster-Brochure Designed For Mailing. U.S. Army Air Forces, Recruiting Publicity Bureau. Courtesy of Northwestern University Library, World War II Poster Collections (ww1645-85).

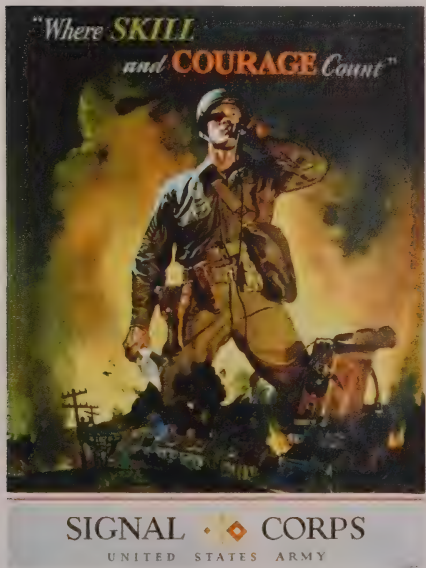


Fig. 22. 1942. U.S. Army Signal Corps. Jes Wilhelm Schlaikjer. Author's Collection.

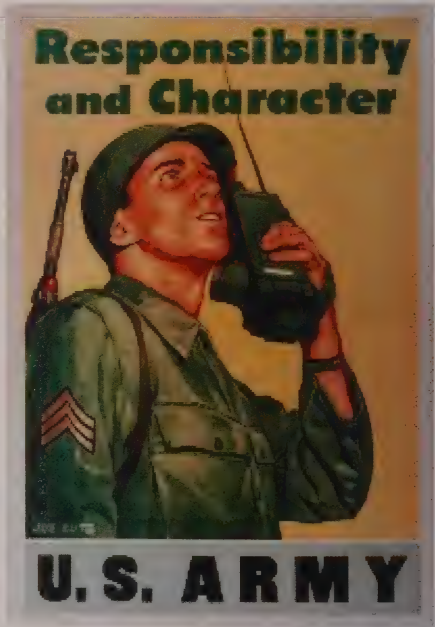


Fig. 23. WWII. Joe Zutz. Courtesy of WA4KCY in Military Radios, 2010.

a set (Fig. 24). The style of this unattributed image hearkens back to the 1919 poster by J. McGibbon Brown, "Enlist In The Signal Corps" with its stylized line drawing.

The Army would not feature its radio and telecommunications technology again until the 21st century. Instead, it favored the appeal of high tech battlefield applications and space age fighting men. Tanks, helicopters and aircraft would continue to dominate poster images until the present.

Army developed a new strategy for combating international terrorism and the nations that sponsor terrorist organizations. Military operations, including those in Iraq and Afghanistan beginning in 2001, have heavily relied on Special Forces units and modern digital communications.

For the first time since the mid-1960s, Army recruiting posters have begun to feature communications related messages. The posters typically consist of photos with soldiers using satellite antennas, field radios, public address systems



Fig. 24. 1965. U.S. Army Signal Corps. Author's Collection.

21ST CENTURY RECRUITING

The modern Army has relied on an all volunteer force since conscription ended in 1972. In order to fill that need, the U.S. Army Recruiting Command was reorganized in 1983 and again in 1992 to find and attract volunteers. (Padilla, 2002; USAREC, 2004) Tasked with finding 70-75,000 new recruits per year, the Army has recently shifted its emphasis toward team building following an enterprise level assessment of its needs and performance. (USAREC, 2009)

In the days following the 9-11 attacks on the U.S. in 2001, the

or computer technology. Graphics have shifted away from drawings, watercolors and advertising art based on paintings, toward the use of photo montages and computer graphics. In addition, the Army has significantly modernized its distribution mechanism. Many of the posters are now available on the internet and can be downloaded for private printing.

In recent years, the U.S. Air Force has taken a similar approach. In "Perfect Execution" the depiction of individual communication and teamwork mirrors the

Army's "Answer The Call" poster prepared for the U.S. Army Rangers (Figs. 25, 26). Both posters hearken back to an earlier time when soldiers were portrayed in the field using communications equipment, as in "Responsibility and Character" and "Where Skill and Courage Count" from World War II.

World War II marked the peak of U.S. government poster production and the use of military recruiting posters. Posters were effective because they tapped into the images and sentiments that Americans recognized in popular culture. They were simple and straightforward, and adapted accepted advertising images from both the past and present. Sometimes sentimental, sometimes melodramatic, they sent their message effectively with few words. (Witkowski, 2003; Aulich, 2007) Now, after more than a century of recruiting, it appears that the U.S. Army and U.S. Air Force posters have at last returned to their original messages; showing the importance of communications in battle and the steadfast resolve of soldiers and airmen committed to defeating the enemy.

ACKNOWLEDGEMENTS

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REFERENCES

- ADT. (2010, Jan. 29). *History of ADT Security Internet Site*. See http://www.adt.com/about_adt/company_history.
- AskArt. (2009, Feb. 24). *AskArt.com Internet Site*. See http://www.askart.com/askart/k/william_krieghoff/william_krieghoff.aspx
- Aulich, J. (2007). *War Posters: Weapons of Mass Communication*. London: Thames & Hudson.
- Bart, D. and Bart, J. (2006). Morse code training devices. *AWA Review*. Bloomfield, New York: Antique Wireless Association. Vol. 19.
- Bart, D. (2010, Feb.). The SCR-536 "Handie-Talkie". *ARCI News*. Antique Radio Club of Illinois.
- Big school for coast artillery: Fort Monroe, Va. to be training center for every branch of coast defense. (1907, Aug. 15). *New York Times*.
- Bird Jr., W. and Rubenstein, H.R. (1998). *Design For Victory: World War II Posters on the American Home Front*. New York: Princeton Architectural Press.
- Boyne, W. (2009, Feb.). They wanted wings. *AIR FORCE Magazine*. Vo. 92 No. 2.
- Burns, B. (2009, Oct.). Atlantic cable broadsides. *History of the Atlantic Cable And Undersea Communications Internet Site*. See <http://atlantic-cable.com/Ephemera/Broadsides/index.htm>.
- Chadwick, H. (1918). *Handbook Of Instructions And Guide To Marconi Wireless Telegraph Records*. Camden, New Jersey: The Marconi Institute of New York and Victor Talking Machine Co. Issued with the phonograph recordings "Marconi Victor Course in Wireless Telegraphy" dated 1922 produced by Victor Talking Machine Co.
- Chambers II, J.W. (2000). War and the Military in Illustration. *The Oxford Companion to American Military History*. Oxford University Press. Retrieved March 09, 2009 from Encyclopedia.com: <http://www.encyclopedia.com/doc/1O126-IllustrationWarndthMltryn.html>.
- Creel, G. (1920). *How We Advertised America*. New York: Harper & Brothers Publishers.
- Darracott, J. (1974). *The First World War in Posters*. Imperial War Museum. New York: Dover Publications.



Fig. 25. Post 2003. U.S. Air Force Special Operations Command. Courtesy of USAFSOC, 2010.

Drill Regulations for Field Companies of the Signal Corps (Provisional). (1911). Office Of The Chief Signal Officer, U.S. Army Signal Corps. Washington, D.C.: U.S. Government Printing Office.
 Gallo, M. (1972). *The Poster In History*. New York: American

Heritage Publishing Company.
 George C. Marshall Foundation Research Library Poster Collection. *George C. Marshall Foundation Internet Site*. See <http://marshallfoundation.org/library/index.html>.
 Hutchison, H.F. (1968). *The Poster:*

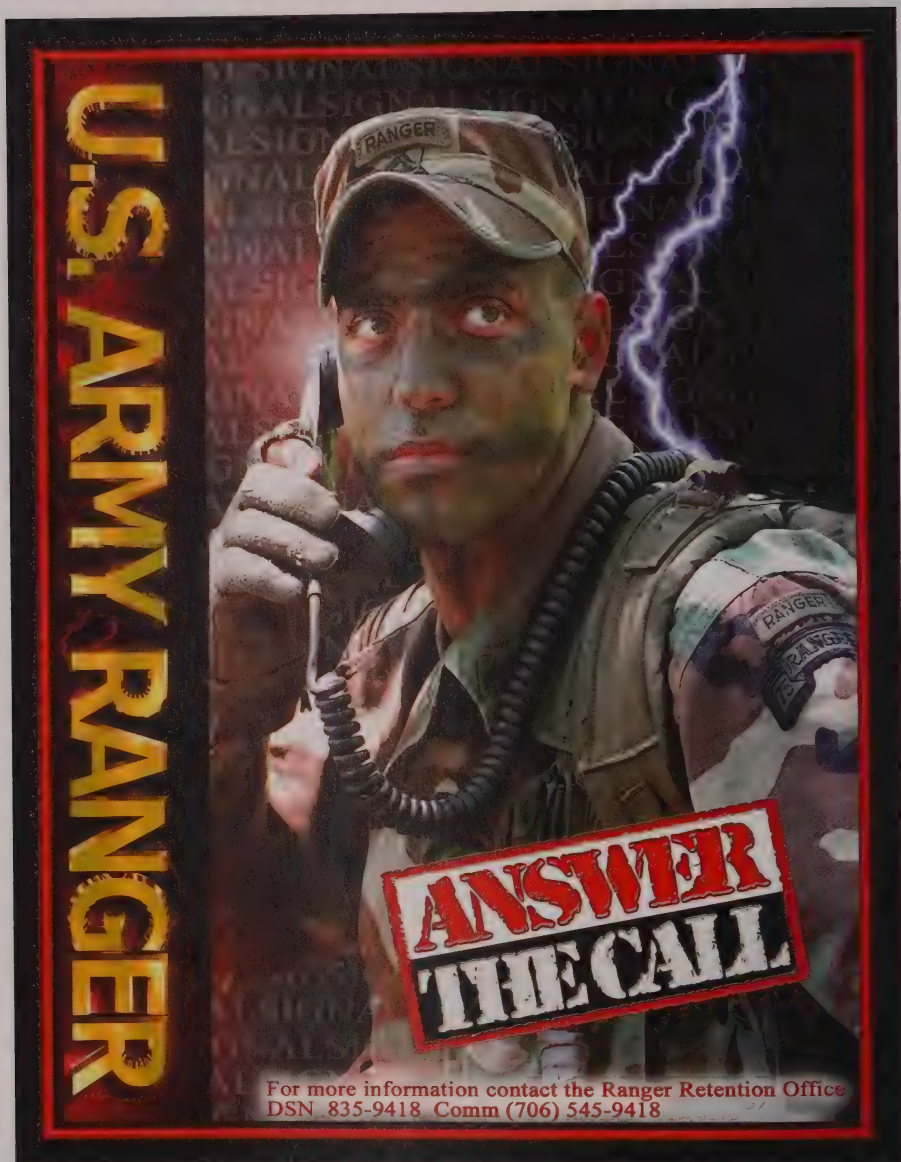


Fig. 26. Post 2003. Nancy Fisher. U.S. Army Special Operations Command. 75th Ranger Regiment. Courtesy of USASOC, 2010.

An Illustrated History From 1860.
New York: The Viking Press.

Military radios. (2010, Jan. 4).
WA4KCY Internet Site. See <http://www.wa4kcy.com/>.

Minnesota Historical Society. (2010, Jan. 13). Visual Resources Database. *Minnesota Historical Society Internet Site*. See <http://>

www.mnhs.org/index.htm.

Morse, S. (1850). The Samuel F. B. Morse Papers At The Library of Congress. *Library of Congress American Memory Internet Site*. Series: General Correspondence and Related Documents; Bound Volume; 24 October 1849 to 19 March 1850; Image 200. See

- <http://memory.loc.gov/ammem/sfbmhtml/sfbmhome.html>.
- Motorola. (1994). *Motorola: A Journey Through Time and Technology*. Motorola Museum of Electronics. Schaumburg, Illinois: Motorola University Press.
- Museum and Online Archive of California Internet Site - Calisphere. (2010, Jan. 29). See <http://www.lunacommons.org/luna/servlet/allCollections>. American District Telegraph. Image ID 47516. Robert B. Honeyman, Jr. Collection of Early Californian and Western American Pictorial Material, BANC PIC 1963.002:0001-1886, University of California Bancroft Library Collections. Berkeley, California (Bankcroft Image ID: BANC PIC 1998.010:02—FR).
- Northwestern University Library World War II Poster Collection. (2008, Nov. 7). *Northwestern University Library Internet Site*. See www.library.northwestern.edu/govinfo/collections/wwii-posters/.
- Padilla, P.A. and Laner, M.R. (2001, Fall). Trends in military influences on army recruitment: 1915-1953. *Sociological Inquiry*. Austin: University of Texas Press. Vol. 71, No. 4.
- Padilla, P.A. and Laner, M.R. (2002, Summer). Trends in military influences on Army recruitment: 1954-1990. *Sociological Inquiry*. Austin: University of Texas Press. Vol. 72, No. 3.
- Pierpont, W.G. (2002). *The Art & Skill of Radio-Telegraphy*. CW FISTS: The International Morse Preservation Society.
- Poster Handbook: A Plan for Displaying Official War Posters*. (1943). U.S. Office of War Information. Washington, D.C.: Government Printing Office.
- Powers of Persuasion (1994). *U.S. National Archives and Records Administration Special Exhibit Internet Site*. See http://www.archives.gov/exhibits/powers_of_persuasion/powers_of_persuasion_home.html, May.
- Produce For Victory: Posters on the American Home Front (1941-45) Internet Site*. (2009, Dec. 28). National Museum of American History, Smithsonian Institution. See <http://americanhistory.si.edu/victory/>.
- Radiotelegraphy*. (1916, Oct.). Office Of The Chief Signal Officer, U.S. Army Signal Corps. Washington, D.C.: U.S. Government Printing Office.
- Raines, R. (1996). *Getting The Message Through: A Branch History Of The U.S. Army Signal Corps*. Washington, D.C.: U.S. Army Center of Military History.
- Rawls, W. (1988). *Wake Up America! World War I and The American Poster*. New York: Abbeville Press Publishers.
- Report of the Chief Signal Officer To The Secretary of War*. (1919). Washington, D.C.: U.S. Government Printing Office.
- Rickards, M. (1968). *Posters of the First World War*. New York: Walker and Company.
- Robison, Capt. S.S. (1919). *Robison's Manual Of Radio Telegraphy And Telephony For The Use Of Naval Electricians*. Annapolis, Maryland: United States Naval Institute.
- The Signal Corps (a). (1956). *The Signal Corps: The Emergency*. The United States Army in World War II: The Technical Services. Washington, D.C.: Center of Military History, U.S. Army.
- The Signal Corps (b). (1957). *The Signal Corps: The Test*. The United States Army in World War II: The Technical Services. Washington, D.C.: Center of Military History, U.S. Army.
- The Signal Corps (c). (1966). *The Signal Corps: The Outcome*. The United States Army in World War II: The Technical Services. Washington, D.C.: Center of Military History, U.S. Army.
- USAFSOC (2010, Jan. 5). *U.S. Air Force Special Operations Command Internet Site*. See <http://www.afsoc.af.mil/index.asp>.
- USAREC. (2004). *U.S. Army*

Recruiting Command History.
U.S. Army Recruiting Command
G-5 Public Affairs Office.

USAREC. (2009, Nov. 6). *Pocket Recruiter Guide 2009.* U.S. Army Recruiting Command G7/9 Public Affairs Division.

U.S. Naval Historical Center. (2008, Nov. 7). *Department of the Navy Historical Center Internet Site.* Recruiting posters for women from World War II -- the WAVES. See www.history.navy.mil/ac/posters/wwiiwomen/wave1.html.

University of North Texas Libraries Digital Collections Internet Site. (2008, Nov. 7). See <http://digital.library.unt.edu/>.

USASOC. (2010, Jan. 4). *United States Army Special Operations Command Internet Site.* See <http://news.soc.mil/imagery/posters/posters.htm>.

Witkowski, T.H. (2003, Spring). World War II poster campaigns: preaching frugality to American consumers. *Journal of Advertising.* American Academy of Advertising. Vol. 32, No. 1.

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David and Julia Bart live in a suburb of Chicago. Together, they have published numerous articles about electronics and communications history.

David received his Bachelor of Arts Degree in Anthropology and Statistics (1985) and his Masters Degree in Business Administration (1993) at the University of Chicago. He is a member of the Board of Directors of the Antique Wireless Association, Technical Curator for the Museum of Broadcast Communications in Chicago, and President of the Antique Radio Club of Illinois. He is also a member of the Radio Club of America. He has been a featured speaker about communications history at the New York Historical Society, American Association of Physics Teachers and American Associa-

tion For The Advancement of Science Joint AAPT/AAAS Meetings in Chicago, and the Antique Wireless Association.

Julia received her Bachelor of Arts Degree in Behavioral Sciences (1987) from the University of Chicago and a Master of Arts in Reading Education from Concordia University (2007). Julia is a long time member and past Treasurer of the Antique Radio Club of Illinois where she continues to play an active role as a volunteer. Julia also volunteers at the Antique Wireless Association. She is a co-editor of the Antique Radio Club of Illinois Newsletter and co-author of numerous articles about communications history. Recently, Julia and David assisted the Institute of Electrical and Electronics Engineers (IEEE) in developing their internet resources on the history of The Edison Medal, the oldest and one of the most prestigious medals awarded in the electrical arts.

David and Julia are founding members of the Webster Club, which focuses on the history of scientific instruments at the Adler Planetarium in Chicago. They have collected radio, telephone, phonograph and telegraph devices for over 20 years; and, with their two sons John and Michael, have enjoyed providing demonstrations and programs for the Boy Scouts of America, school groups and local historical societies.



Julia and David Bart

AWA Review

The 1000Z Stratosphere: Zenith Radio Enters the Black Dial Era in Grand Form, 1933-1937

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ABSTRACT

To learn the history of the Zenith Radio Corporation, one must appreciate Commander Eugene F. McDonald. Both a genius and risk-taker, his influence brought about several inventions and innovations. One of them was the Big Black Magnavision Dial, which was first employed on a 25-tube console. This radio, the Stratosphere—due to its scarcity and luxurious styling—has become the Holy Grail for many collectors of vintage radio sets. While very few of the Stratosphere units were produced, they served very well as a promotional device in advertising all of Zenith's lower priced 1936 *black dial* models. Sales volume for the 1936 line increased by at least 2.5 times over the 1935 model sales volume. For the 1937 model line, sales doubled yet again. This paper tells the story of the Zenith Stratosphere, from inception through engineering, production, sales, and its legacy to the radio collecting community.

Commander Eugene F. McDonald, the president of the Zenith Radio Corporation from its inception until his death in 1958, appeared to be the “engine” behind many of the ventures Zenith undertook. One was the Transoceanic Clipper short wave portable. Others included the Radio Nurse; the Radionic Hearing Aid; the Arm Chair style of radio models (chairside); the Split-Second indicator for Zenith's Big Black Airplane dial; the inverted Bakelite chassis table models of 1940; and Phonevision, a subscription television service, much like today's cable TV. One venture that McDonald affected has had little written about it—the development of Zenith's distinguished 1000Z Stratosphere radio console.

Many collectors of vintage radios have searched for many years to find the radio console that is considered to be the culmination of Zenith's household radio product market. Its scarcity, along with its beautiful art deco cabinet and its robust circuitry helped build its legendary status in the radio collecting community. When Zenith began producing this model in late 1934, it ushered in the era of Zenith's “Big Black Dial” radio sets, which continued through the late 1940s.

Beginning in the mid-1920s, Zenith produced several prestige radio models. The Super-Zenith X began this tradition and was quickly followed with the five deluxe models (the Spanish Deluxe retailed for \$2,500). Later, the ornate and massive 40A Italian Renaissance style radio-phonograph combination retailed for \$850. Other subsequent models in 1929-1930 qualifying as prestige models would have been models 55 (\$750 and later \$700), 67 (\$545), and 78 (price unknown), all using the same massive Italian Renaissance cabinet having a stretcher base. A wired remote control manufactured by Utah Radio Products was standard equipment



Fig. 1. Promotional photograph of the famous Zenith 1000Z Stratosphere radio console. This is the early version having four main control shafts. Two more controls were added above the dial on later releases. Note the décor used in the photo—triple-striping on the walls, blue and gold color harmony, a potted Mother-in-Law's Tongue, and a figural cat—all blended with this fine instrument produced by Zenith in the finest Art Moderne style of the mid-1930s.

on a couple of these models.

The stock market crash in October 1929 and the ensuing depression spurred retrenchment at the Zenith Radio Corporation plant. The prestige market had essentially dried up. Lowering the mean price of an average set in the model line, Zenith introduced the

Zenette line of low-priced models in 1931. The most expensive Zenith model of 1931-1932 was the Zenith Louis XVI styled "Ultra" or "Hyper-Heterodyne" model # 103 highboy console at \$290, which also happened to be in the first Zenith line employing Armstrong's Super-Heterodyne circuit. Model

103 was a beautiful set and also employed 14 tubes, one of which was a power regulator (ballast).

So little is known about pricing of models of the 1933 and 1934 model lines, but it would appear that the 12-tube models 440, 441, or 617 were at the top of the line. For 1935—Zenith's first line employing an airplane dial (in a light tan color)—model 990, also a 12-tube console, immediately preceding the Stratosphere in model number and release, sold for \$250. These were all nice radio consoles, but not strikingly luxurious. Following the tradition of prestige models which Zenith previously produced, McDonald believed that Zenith should resurrect production for this prestige market shortly after he viewed the E.H. Scott line of deluxe consoles.

Much of the information regarding the Stratosphere presented herewith came from Commander

McDonald's corporate files which were sealed shortly after McDonald's death in 1958 and unsealed in the early 1990s. These files documented much of McDonald's day-to-day correspondence and activity at Zenith. The files start around 1927 and cover thirty years of history. Professors John Bryant and Harold Cones cataloged and re-boxed these files into approximately 265 file storage boxes. Much credit is due John Taylor, Zenith's current Public Relations Vice President for protecting this priceless archive.

THE INSPIRATION

The E.H. Scott Radio Company produced high-performance radio chassis and luxurious cabinets for the discriminating customer. Although it produced relatively few radio sets as compared to large U.S. radio manufacturers, word traveled fast among the affluent: Scott was a fine instrument and the radio to buy.

McDonald learned of E.H. Scott's products. On April 13, 1933, McDonald sent the following interoffice memo that apparently had some Scott literature attached to it. It indicates the first interest, on McDonald's part, in returning to the prestige market:

Messrs: Klugh, Tracey, Robertson, Hassel, Jarvis

Wish you would look over this E.H. Scott line of Deluxe sets, which he is finding some customers for throughout the United States. This is an interesting racket. If you want more details, they can be given to you by Mr. Whiting who called on the [E.H. Scott] factory.

Whiting was a Cost Estimator for Zenith in the early 1930s. He established the total production



Fig. 2. Commander Eugene F. McDonald, President of the Zenith Radio Corporation, on the deck of his yacht, the Mizpah.

and parts costs for proposed Zenith radio models of the day. It is therefore apparent that Zenith was looking into the feasibility of producing a comparable model to the Scott models.

E. H. Scott's latest model was the "Allwave 12 Deluxe," introduced around May of 1932 at a retail price around \$115 to \$150 for the chassis. The chassis produced for this model consisted of an upper chassis having nine tubes and the lower chassis having the remaining three. It was also the first Scott chassis to be entirely chrome-plated.¹ The Scott cabinet, selectable from a variety of styles, was purchased separately.

Late in 1933, with the 1000Z clearly in the design phase as evidenced in the following letter, McDonald elaborated on E.H. Scott's position in the prestige market:

Only last evening I was talking with the president of a French auto company. He asked me what I knew about the Scott radio. I told him it was a small concern here in Chicago building custom-made jobs. He said that he had heard of the set first when he was abroad and that since coming over here he had heard of it through Mr. Kettering, the Vice-President of General Motors in charge of engineering and Mr. Sorenson of the Ford Company; that he had been given to understand that it was the greatest set made in the United States; that it would reach out to all points of the world.

I am getting this right and left. I see no reason why we should permit this Scott Company to step into the position which we have always occupied. I believe that in building our 25-tube set, we should produce a set having in it everything

including the expensive construction where necessary that is used by the Scott Company. I believe we should have one at a lower price than the 25-tube can be built at. In other words, the Scott Company should not be permitted to continue to grab this high-class name.²

McDonald's proposal in the latter paragraph likely resulted in the development of the 16-tube Stratosphere models 16-A-61 and 16-A-63, which reached the market in the fall of 1935, well after the introduction of the 1936 Zenith line, which occurred during the summer of 1935.

As Zenith designed the chassis for the 25-tube set, E.H. Scott introduced the 15-tube model "Allwave 15" around February 1934 at a price of \$155.00 to \$169.81. The "Allwave 19" was introduced around August 1934 at a price of \$1,500 in a Warwick Grande cabinet. It also employed a record changer, recorder and a microphone. It used twelve tubes in the main chassis and the other seven in the power supply chassis.¹

Zenith's Stratosphere would be comparable to the E.H. Scott line of deluxe consoles. Zenith previously used mammoth-sized chassis in earlier prestige models, such as the one used in the Deluxe models. Like the Scotts, the Stratosphere would also use a chrome-plated chassis.

THE CABINET

Frank I. Johnson (April 2, 1879-September 5, 1952) of Rockford, Illinois, designed the cabinet for the coveted 1000Z 25-tube Stratosphere. A well-known local artisan, he owned a designing firm in Rockford and operated for a few years with a business partner, Titus. Of the many Zenith cabinets designed before World

War II, the cabinet used for the Stratosphere was one of the elite few to have been patented. The application was submitted in July 5, 1934. It was assigned US design patent #93,274.³ Johnson possibly designed several other Zenith cabinets, although the writer found no patents issued for them. The slotted pilasters characterized several of the better 1935-1937 Zenith consoles, such as models 985 and 12A58.

Sept. 11, 1934.

F. I. JOHNSON
RADIOCABINET
Filed July 5, 1934

Des. 93,274



Fig. 3. Patent drawing of the cabinet designed for the 1000Z Stratosphere. Zenith modified the cabinet in the vaulted speaker grill area by: 1) adding additional fluting in the upper center for the horn tweeter; 2) dividing the long, continual fluting on the flanks into two separate flutes, upper and lower, to provide some strength to the center of this thin, plied grille. The pilasters that flanked the vaulted area remained as drawn.



Fig. 4. Gilbert E. Gustafson, hired by Zenith to operate Zenith's station at Mt. Prospect in 1925, became the Chief Engineer of Zenith by the age of 29 years.

THE DIAL

Around 1934, the small keyhole type of radio dials and escutcheons were rendered obsolete in the radio manufacturing industry by the advent of the large round airplane dial. This new dial had a hub at the center and may have been named due to the likeness to the cockpit instruments and displays in aircraft of the day. It is also possible perhaps that it reminded people of an airplane propeller.

AN IMPROVEMENT TO AIRPLANE DIALS

Commander McDonald realized that there was a problem in tuning on the shortwave bands. In these days before band-spread tuning, the stations were so tightly packed in certain frequency ranges that trying to relocate these stations after tuning to other stations or wavebands, it was frequently dif-

ficult to retune to the desired station. Picture the way it was with only one pointer on the airplane dial: when turning the knob only slightly, several station frequencies could be swept across with hardly any movement of the dial pointer. How would the listener know that he had re-acquired the right station?

McDonald had an idea: why not add a *second* pointer, much like the *second hand* of a watch or clock? This pointer would turn at many times faster than the main pointer, which would allow accurate recording or referencing of the frequency location of the desired station via referencing an added "logging" scale. He filed for the patent for this idea on September 1, 1934. U.S. Patent # 2,052,238 was effective on August 25, 1936. It became known as the "Split-Second" dial and was employed on the better Zenith models beginning with the 800 series in 1934-35, one year before the black-dial lines started.

ENGINEERING THE EDGE-ILLUMINATED DIAL

In September of 1934, the scheme for the dial was on the drawing board. Gilbert E. Gustafson, Zenith's Chief Engineer, proposed a variation of the dial being designed for the Stratosphere, and subsequently, the 1936 line. This proposal would have one-half of the dial scale darkened similar to Atwater Kent's idea. Commander McDonald rejected it because in his mind, it lessened the value of the split-second tuning since, McDonald stated, many people tune their radio at night when the room lights are out.⁴ This would explain the separation of the split-second tuning into its own dial scale on the Stratosphere—one that would be illuminated at all times, regardless of which waveband was selected.

This also led to the provision for split-second scale being placed on the dial glass on the 1937 model 12U158 and 12U159, since each waveband was exclusively illuminated by rotating the waveband switch.



Fig. 5. Hugh Robertson, Zenith Treasurer

Edging closer to completion of the engineering phase of model development, on October 8, 1934, Hugh Robertson reported to McDonald the status of Stratosphere development:

Have asked Mr. Tracey to talk with you on the Deluxe 25 Tube set. I called the factory and laboratory people together last Thursday for the purpose of finding out just where we stood on development and delivery. Briefly, the situation is as follows:

There is still about two weeks' development needed.

We can start immediately on some of the dies and, of course, we can order some of the materials. If development is completed within two weeks and we use only sample dies where necessary it would be possible to start bringing through sets in about five to six weeks, completing 100 by about December 6.

Estimated costs are stated as follows:

Chassis Materials	\$70.78 including safety factors
Cabinet	\$58.14 including safety factors
Labor	\$8.80 including safety factors
Total	\$137.72

It is difficult to estimate die charge without knowing quantity we will make but it appears that it will cost about \$15 to \$18 per set on the first 100 sets for either temporary dies or extra labor if parts are made by hand. Therefore, total prime cost on the first 100 sets would be approximately \$150.

The sale price of this set is	\$750.00
Discount is 60% and 10% making distributor's price	\$270.00
Deductions for royalties, cash discount, advertising, etc. 20%	\$54.00

Making our NET RETURN	\$216.00
Deduct Total Prime Cost as above	\$150.00
Balance for contribution to overhead	\$66.00

Mr. Tracey will analyze the orders which he has for these sets and report to you.

I feel that we are committed to produce some of these sets as soon as possible and we should start immediately unless Gustafson has any doubts about being able to make the set work.

I do not like the glass dial—it is too much of a novelty and does not fit in with a nice piece of furniture.

Laboratory expenses for development of the Stratosphere were \$958 for the month of November 1934, and \$7,422 spent on the project since May 1, 1934, the beginning of the fiscal year. Total Engineering expenses for the month of November were \$7,424 and for the seven months since May 1 were \$65,499.⁵ This yielded 12.9% to Stratosphere development for November and 11.33% since the beginning of the 1934-35 fiscal year. There was roughly one year of development on the Stratosphere in the previous fiscal year of 1933-34.

A subsequent upgrade consisting of the local-distance switch, the tweeter switch, waveband coverage, and circuitry changes

may have been completed after the first release between October 1934 and February 1935. According to service literature, serial #754107 would have been the first chassis to incorporate these new revision changes.

NAMING OF RADIO MODELS

No records of development of a name for what became known as the Stratosphere radio model could be found by this author. As with several other innovative radios that McDonald championed, he and other Zenith's top executives corresponded with each other listing catchy potential names for submittal to the other executives within the group as a sounding board for name selection. Irving R. Allen, a

friend of McDonald and Zenith's agent for the E.H. Brown Advertising Agency was particularly adept in naming radio models, creating advertising slogans, and creating effective promotions to sell radios. The Radio Nurse, the Ravox, the Transoceanic, the Wavemagnet, Consol-Tone were just a few of the engaging names that the top management solicited through brainstorming sessions and correspondence.

About this time, there were many balloon explorations by those investigating the high altitudes above the troposphere. A highly promoted joint expedition by the National Geographic Society and the U.S. Army Air Corps in the summer of 1934 explored the stratosphere. A large article appeared in the October 1934 issue of the National Geographic Magazine covering this event.⁶

Also notable were scientist Dr. Jean Piccard and his wife, Jeanette, who set a record and made newspaper headlines on October 23, 1934 when they ascended into the stratosphere to an altitude of 60,000 feet using a balloon with a pressurized gondola. Jeanette piloted the balloon, which lifted off in Detroit and landed near Cadiz, Ohio. The experiment was not to set a height record, but rather, to study cosmic rays.⁷

Perhaps these experiments or other ballooning expeditions around that time were the impetus for Zenith naming the new 25-tube set the "*Stratosphere*," but this is pure speculation on the author's part. Insofar as the McDonald files show, there was no record of the 1000Z being referred to as the Stratosphere before the time of the Piccard flight.

PROTOTYPES

While Gustafson was in New

York at the National Electrical and Radio Exposition in September 1934, McDonald gave him some suggestions:

Don't fail to look up the Magic Brain thought of RCA. Also their ex-wave which takes in the weather and which our fellows seem to know little or nothing about. [sic] I think you will probably find that RCA has a point where they are demonstrating. I suggest that you see this demonstration. I also suggest that you also go to wherever Philco is demonstrating and particularly where Stromberg Carlson is demonstrating this loudspeaker. I feel that you should remain adamant against our demonstrating the 25-tube set that is now in New York.⁸

It is therefore evident that one or more prototypes were in the field as early as September. No explanation could be found for McDonald not wanting Gustafson to demonstrate the Stratosphere at the show, except that the Stratosphere was still in development and would not be completed until late October. Perhaps the dial or bezel hardware was still not finalized or McDonald did not want to "show his hand" to the other manufacturers. Perhaps there were technical issues that had not been resolved yet. The radio model may not have been given the "Stratosphere" name yet, but, as before discussed with the balloon flights in October 1934, this is pure speculation on the author's part.

PRODUCTION COMMENCES

A production release for 100 units was authorized by October 29, 1934. Table 1 shows the flow of the Stratosphere at various stages in the production process. As

the author can personally attest, when “ramping-up” production at an electronics plant on a new product, the shipment forecast numbers and dates are often too optimistic. Parts shortages are a major cause. Test failures requiring engineering intervention are another major cause, as are discrepancies preventing the approval of the “First Article” inspection.⁹ Robertson believed that 100 units could be shipped by December 6, which was too optimistic. It is not known which factor held up shipment. The schematic was dated November 19, 1934, which probably preceded any production, since all drawings would need to be completed before production and testing.

McDonald had his best man personally handle demonstrations of the Stratosphere, such as this one in Milwaukee:

Gustafson:

The demonstration is set for the 25-tube set in Suite No. _____ at the Shorecrest Hotel for 3 o'clock on Friday. Now for heaven's sakes don't wait until 2 o'clock to get your set in there.

I have also arranged to have a doublet antenna put in, a ten tube console and a six tube midget. This part is taken care of. You take care of the Stratosphere end of it.¹⁰

On January 28, 1935, a production release for 100 more units was authorized, giving a total of 200 authorized to that date. On January 31, 1935, the second production release was amended to 150 units, giving a total of 250 units released.¹¹

McDonald exercised some control over testing procedures for the Stratosphere. One example is

from early 1935 and regards a vibration table “shaker” test for the 25-tube Stratosphere chassis. He communicated with Mr. Arthur Freese, urging him to shake the chassis before assembly of the dial glasses, since having the glasses installed could shatter the glass. Communicating with Gustafson, McDonald wanted to know how many chassis failed as a result of the vibration test.¹²

McDonald's personal glimpse of the development of the 1000Z Stratosphere is revealed in correspondence between McDonald and a good friend, Charles J. Iredell, a General Agent for the Penn Mutual Life Insurance Company. Charles heard through a friend who was a radio aficionado that Zenith was building a 20-tube set. Charles requested literature on it for himself and his friend.¹³

McDonald replied:

My Dear Charlie:

Thanks for your letter of February 1.

I am sending to you under separate cover a copy of the literature on the 25-tube set. This lists at \$750.00.

I am also sending the same literature to your friend, Mr. Stuart Anderson, at address given.

We have gone rather slowly on the production of this set, although we have had it in mind and have been working on it for over two years. We did not know whether the public was ready for it as yet. We decided to build them only in a custom way, putting thru [sic] an order for only 1,000 at a time and then only as our distributors and dealers ordered them from us.

Imagine our surprise when the samples of these got out

and the dealers and distributors were wildly enthusiastic over it in spite of the \$750.00 price. We are now so far behind in deliveries that the next delivery for which we can accept orders will not be thru for five or six weeks—maybe seven. The sets that are coming thru are now allotted to various distributors thruout [sic] the United States. As fast as they receive the sets their dealers draw lots to see who gets them. The reaction to this set has been a complete surprise to us, because we thought the \$750.00 price would stop the sale of it regardless of its outstanding performance.

Now on the subject of performance, it will do no more European stations than our 11 or 12 tube sets, that is, it won't bring in any stations that the 11 or 12 tube sets won't bring in, but as for the tone quality, well Charlie, you have never heard anything like it. It is just unbelievable that reproduction can be brought thru a mechanical or electrical instrument as this does it.¹⁴



Fig. 6. Ray Burnet

Ray Burnet, Comptroller for Zenith, produced a report for McDonald based on his visit to the J.A. White Distributing Company of Grand Rapids, Michigan, the Zenith Distributor for that area, in early February 1935. Ray voiced a concern for a problem that White noticed with the Stratosphere cabinet:

There is a black strip of wood across the front of the cabinet, just below the tuning dial section which is going to give trouble, in that because of the heat and moisture coming from the resting of the hand while tuning, the black wears off, leaving a very noticeable white streak, particularly so on the edge. Mr. White suggested that this piece of black wood be replaced with some such material as Bakelite. This is similar treatment to that given by the refrigerator people on their production. In their case, however, there is more than just looks, but it is more practical because of other materials being more absorbent.¹⁵

Ray commented on White's handling of the Zenith line:

The writer was very much impressed with the display room of the distributor, and the activity of the dealers in that display room yesterday. I was in their office approximately 7 hours, and the Stratosphere was turned on about 8 times. This indicates the frequency of visits by dealers, and resulted in the sale of several radio receivers. There were two model 978 (samples) received by them yesterday, and they seemed to be very much pleased with them. They also received a shipment

from us consisting of 25 model 975 and 5 model 847. When I left late yesterday afternoon there remained only 12 model 975, no 847, and they had sold and shipped a few model 807 and 1 model 970. Repeat orders were received from Kalamazoo for 6 model 975 which were included in the above referred to shipment. It is apparent to me that this distributor at least is really actively merchandising this model, and they have requested that we supply immediately at least 15 additional 975 ad mats. I believe, therefore, that Mr. Ericksen will ship at least 10 of these today.¹⁶

ers Laboratories, and four to be billed by Memorandum to McDonald, Tracey, McKelvey, and R. I. MacClellan. Burnet's worksheet shows that McDonald was in possession of s/n 754002 (and power supply s/n 6002), and that MacClellan had 754084 (6084).¹⁷ McClellan was the District Sales Manager for Zenith in the eastern Midwest (Ohio and portions of all states bordering Ohio). Four units were also shown as "packed" on February 9.¹⁸ This would still leave one set unaccounted for.

On February 8, 1935, McDonald asked Ray Burnet to account for the first order of 100 Stratospheres. Burnet showed 90 billed to distributors, one at Underwrit-

<u>Zenith</u> <u>Stratosphere</u> <u>Model 1000Z</u>	<u>Authorized</u> <u>Production</u>	<u>Shipped</u>	<u>Orders</u> <u>on Hand</u>	<u>Sales</u>	<u>Packed</u>
October 29, 1934	100		136	136	
November 5, 1934	100		136	136	
December 15, 1934	100	1	134	135	
December 22, 1934	100	9	125	134	
December 29, 1934	100	17	119	136	
January 5, 1935	100	29	65	94	9
January 12, 1935	100	58		95	3
January 26, 1935	100	87	24	111	
February 9, 1935	250	94	20	114	4
March 9, 1935	250	97	17	114	2
March 23, 1935	250	108	15	123	1
March 30, 1935	250	111	16	127	
April 6, 1935	250	124	4	128	1
April 20, 1935	250	137		137	20

Table 1. A snapshot of the Zenith Stratosphere after the initial production release

Zenith 1000Z Stratosphere Production vs. Sales

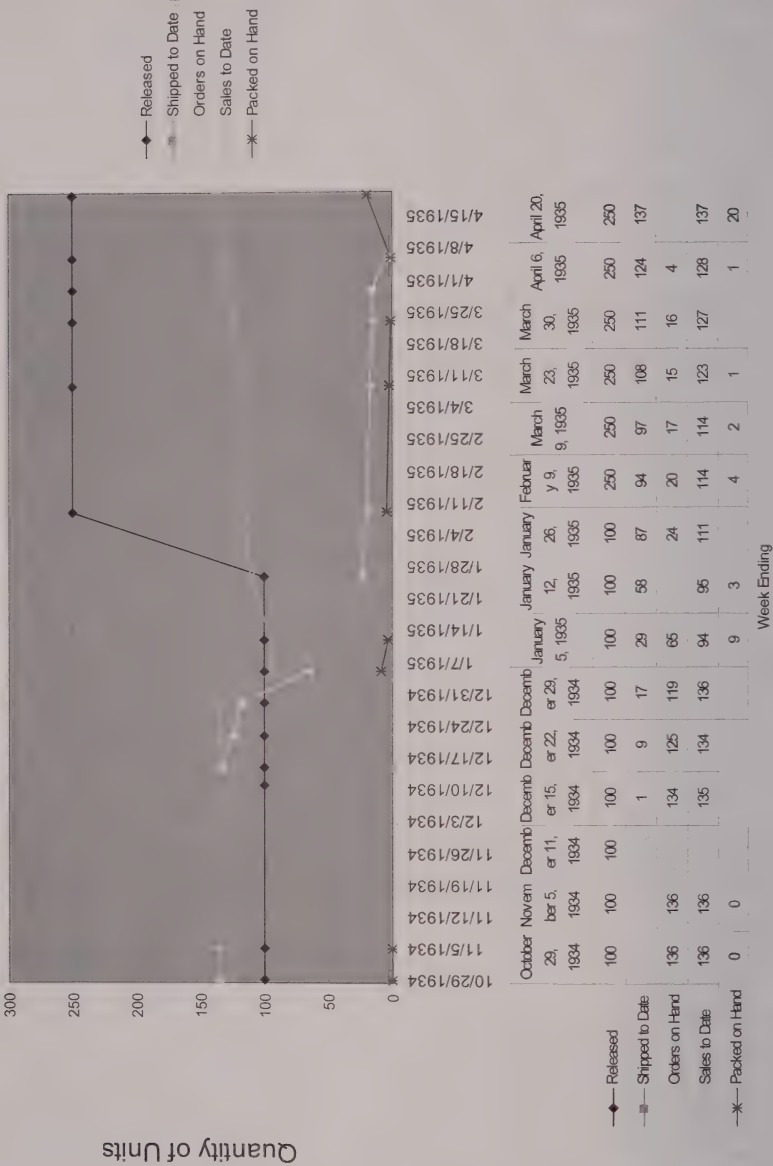


Table 1A. A comparison of metrics of number of units released, shipped, orders-on-hand, sales to date, and packed-on-hand, October 29, 1934–April 20, 1935.

For unknown reasons, two accounts cancelled orders on the Stratosphere just after Christmas of 1934. Fey & Krause, Zenith’s Los Angeles distributor at the time,

cancelled 40 units. The other account, Thompson & Holmes, Ltd., Zenith’s San Francisco distributor, cancelled 33 units.¹⁹ It is very possible that due to the late initial

deliveries of the Stratosphere, the Christmas shopping season was missed. These two cancellations comprised a major portion of the orders in December 1934.

There was somewhat of a pause in production during February (see Table 1). This was probably due to the integration of the subsequent upgrade consisting of the circuitry changes, a local-distance switch, the tweeter switch, and waveband coverage. The schematic for the revised 1000Z was dated February 22, 1935. By the middle of March, the plant began shipping revised units from the second release.

Radio News announced the Stratosphere in April 1935:

Here is an interesting announcement on the new Zenith Stratosphere 25-tube set, equipped with three speakers and employing eight 45 type tubes in a push-pull parallel output power stage. The speaker equipment comprises two concert dynamic-type speakers to handle the low frequency response and a small horn-type dynamic speaker to take care of the high frequencies above 3,000 cycles. The manufacturer states that the frequency range response of the triple speaker combination is from 30 to 8,000 cycles. With 8 of the 25 tubes accounted for, the remaining 17 tubes are employed as follows: six 6D6's for the first and second r.f. stages, the first and second i.f. stages, the shadow-tuning meter and automatic volume control amplifier; one 76 for the second detector and two 76's for the parallel first audio stage, one type 79 as a relay for "Q" circuit, one 6A7 as a combined first detector and oscillator, one 85 a.v.c., two 42's in the second push-pull audio

stage and three 5Z3's as rectifiers. The tuning range of the set is from 535 to 63,600 kc. and is divided into five bands. The set is equipped with the latest developments including a high-fidelity control. Expert craftsmanship is at once apparent in the construction and design of the cabinet housing this unusual receiver.²⁰

It would appear that Zenith just beat Scott to the high fidelity market. Around March of 1935, E.H. Scott introduced his first high-fidelity set in the twenty-three tube "Allwave 23," also known as the Imperial. It employed seventeen tubes on the main chassis and the other six on the power supply chassis. It also employed a small window dial, like previous Scott models. It employed three loudspeakers: a 12" woofer and two tweeters. The price ranged from \$179.50 to 217.50 for the chassis and speakers.^{1,21}

Now on Display in Our Store

The New Zenith

25 Tube

Stratosphere Radio

TWO YEARS IN PERFECTING

The new Stratosphere Zenith represents two years of experiment and research by the world's best qualified radio engineers and the entire facilities and resources of the Zenith factory.

YOU ARE URGED TO COME IN AND
SEE THIS SUPERB MUSICAL INSTRUMENT
AND HEAR IT OPERATE,
WITHOUT OBLIGATION.

It is the only Stratosphere being shown on the Pacific
Coast at present.

NEVADA MACHINERY & ELECTRIC CO.
"Nevada's Pioneer Radio and Refrigeration Dealer"
121 North Virginia St.—Phone 3801

Fig. 7. A newspaper advertisement from the Reno Evening Gazette, dated Thursday, January 3, 1935. This demonstration radio would have been one of the first units shipped.



Fig. 8. Promotional photograph distributed by south-central Pennsylvania Zenith dealers in 1936 showing Lizzie Hoy, a radio entertainer in the Harrisburg area, posing with the 1000Z Stratosphere. This photo shows the revised six-control-shaft axis version. The missing right half of this photograph shows Lizzie standing next to a 1937 Zenith console model 10S156.

RECEPTION PROBLEM ON ULTRA-SHORT WAVE BAND

Gustafson, along with Doc Rafferty, a former Zenith Engineer, tested a police transmitter that Rafferty had built. It broadcasted at 9.75 Meters (roughly 32 MHz) and the reception of the transmission was poor on a Zenith #1001 chassis used in the test, a ten tube type, being 200-300 μV (the lowest level injected from a signal generator that the receiver could detect—the desired level is much lower, on the order of several μV , or microvolts). The following helps explain a condition Zenith noted on the ultra-short wave frequency bands on the Stratosphere:

The first release of Stratospheres had a range in the number 4 band of 10 to 30 meters and therefore, I called McManamon, the final tester in Plant #3, to hook up one of these sets and listen for it. He reported that he could hear it very strong and could understand what was being said. The newer Stratospheres however have a limitation on the 4th band. This range being 12 to 35 meters. Both the old and the new sets however have a 6 to 15 meter range but this range is very poor, the same as in the 10-tube sets. On this range the tubes do not oscillate and it is necessary to use a 2nd harmonic. This is one reason for the poor sensitivity.²²

S.A. Long Electric Company, Zenith's Wichita, Kansas distributor had a complaint about the Stratosphere dial lighting:

NOW ON DISPLAY
A Complete Line of New 1936



From 4 to 25 Tubes
Be Sure to See These Sets Before Buying
The Greatest Value in Radio History
—ALSO ON DISPLAY—

The New Zenith Stratosphere
25 Tubes
The World's Finest Radio

Nevada Machinery & Electric Co.
"NEVADA'S PIONEER REFRIGERATION AND RADIO DEALER"
121 North Virginia Street Phone 3801

Fig. 9. Nevada State Journal, Reno, Nevada, Wednesday, July 31, 1935.

IT'S HERE

Zenith Stratosphere

The 25-Tube, \$750 Radio

HERE UNTIL NEXT WEDNESDAY

— at the —

Square Deal Electric Co.

THE WORLD'S FINEST RADIO IN CHILlicoTHE

FOR 5 DAYS

Come In! See It! Hear It!

It's worth coming a long way to see

STORE OPEN EVENINGS

Fig. 10. Zenith distributors even shipped the Stratosphere demonstration model to small towns for limited showings. This advertisement appeared in The Chillicothe, Missouri Constitution-Tribune on Friday, December 13, 1935.

Gustafson:

Note this objection by S.A. Long – I know he is right. There isn't enough light on the Stratosphere either. Isn't it possible to put more light and get a better effect?²³

McDonald even called on Gus-

boy, that Bedroom Set in Johnston Wherry's Window Sure is Keen!!

... did you see that double deck bed with the ladder on it! And that sweet bunk with all the trunks and things? Oh, boy! Wouldn't I like to have that for my room!

... And the furniture so exciting too and you can ... your kid a real kick out of seeing nice furniture, and for a boy's room (Beverly room tonight and one of the boys' with the only bed in the room) for a few days more.

—n' boy—I sure want to see that big 25-tube radio next Thursday!

As a special attraction to be featured during Johnston-Wherry's **STYLISH SHOW** to be held next Thursday evening, you will see the **EXCLUSIVE STRATTONSPRING** ... the largest, finest and most complete radio in the world!

Mom will enjoy seeing—
... the money saving new, streamlined and especially those beautiful new modern tables and white oak combination.

Dad'll get a kick out'a—
... seeing and hearing more about that new different **GLADYS ROBINSON** Motograph ... the magical music it can turn things in general into ... fantasy representations of what there is right in it.

Sis will rave over—
... those most "Cozy" bedroom suites ... she always has wanted one, and it is great about one like the one at Johnston-Wherry's.

So, the whole family will attend Johnston Wherry's **STYLISH SHOW** on next Thursday evening.

SEE OUR SPECIAL SPRING SHOWING of DRAPES

A complete assortment of domestic and imported drapes ... the finest we have ever shown ...

This Complete Decorative Dept. Is at Your Service

Johnston-Wherry Furniture Co. Photo 24

917 11th

Fig. 11. From an advertisement for the Johnston-Wherry Furniture Company, The Modesto Bee and News-Herald dated March 19, 1935.

tafson to investigate problems on the Mizpah:

Gustafson:

The Stratosphere on the boat breaks up if you try to put it at full volume and entertain the harbor. I have turned the Stratosphere on full volume at the Stevens Hotel and it does not break up. Do you think it is because of the inverter we are using? Why not make a test on the boat of putting in a throw-over switch so that I can either use the inverter or the motor-generator. I'd just like a test made of this. I don't want any permanent installation.



Fig. 12. Dr. Frank A. Rafferty

Just want to have your men see whether that is what is making the difference.²⁴

When it came to posting the design patent for the cabinet, McDonald was concerned about the public discovering that the cabinet was patented on September 11, 1934. If the radio was to continue to be sold in multiple years, he did not want people to perceive that it was an "old" model. He urged that it be listed as "Cabinet design patented, Design Patent No. 93,274" and having no date listed.²⁵ The cabinet patent, however, was not printed in the Installation and Operation manual for the 1000Z.

Just in time for the 1935 Christmas shopping season, Zenith promoted the Stratosphere in the November 1935 *Fortune* magazine with a full-page advertisement. It displayed the revised dial which covered frequencies up to 45 MHz. Around December of 1935, E.H. Scott was dauntless: he introduced the "Quaranta," a forty-tube console consisting of a two cabinets: one cabinet for the radio and an automatic record changer; the

other cabinet for the speakers. Later versions employed 48 or 50 tubes or more and had five speakers. The price for this mammoth combination was \$2,500 including the cabinets.¹ Like earlier Scotts, it utilized a small window type dial.

In mid-1936, McDonald asked Gustafson to investigate the pros and cons of designing a receiver similar to a Capehart. Gustafson replied on July 2:

Messrs: McDonald, Robertson, Tracey, Bryant, Rasmussen

I want to let you know what has been done since receiving your memorandum of June 12, on the subject of designing a receiver on the order of a Capehart.

I visited Lyon & Healy and looked at the Capehart, RCA, and Stromberg combination units. The salesman at Lyon & Healy told me that they had not sold very many of the \$600.00 RCA combination, as they found it quite easy to sell the customer up to the \$1,000 Capehart. As near as I can determine the biggest selling point of the Capehart is the record changer. Certainly the radio set which is incorporated is nothing to write home about. This Capehart record changer will play a record on one side and then turn it over and play the other side. By this arrangement standard records can be used and an entire symphony can be played in the correct sequence. This is not possible with any other record changer on the market.

The only phonograph turntable manufacturer of any consequence in this country is General Industries Company in Elyria, Ohio. I had a conversation with Mr. Moon of that company, and while they have

a large assortment of record changers, they have nothing which compares to any used in the three above mentioned models—Capehart, Stromberg, or RCA, nor do they contemplate manufacturing a larger unit. They said they had considered it many times, but so far nothing has been done about it. I thought it best to investigate the possibility of any of the coin operated phonograph units having such a record changer available. They do not have anything that is suitable. These coin operated machines naturally are designed primarily so the customer can select any one of perhaps ten records, and they are not at all interested in playing both sides of the record.

We have been purchasing record changers and turntables from General Industries in Elyria for several years. In talking with Mr. Moon he told me that Capehart is in financial trouble and that General Industries had a stock interest in Capehart. I am wondering if any pressure could be brought to bear on Capehart through this source to get us this record changer. We are having Mr. Moon stop in here and Mr. Tracey is going to talk to him.

From what I can see, this record changer of Capehart is by far their biggest selling point and without this changer or another which will accomplish the same thing, I feel we will be working at a big disadvantage.

I do not see any point in going ahead with any cabinet or set design until we have decided what kind of a record changer we will incorporate. In order to design an instrument of this type, the entire assembly must be built around the re-

cord changer. Incidentally, the Capehart unit uses a Howard radio.

Jimmy Rasmussen corresponded with McDonald in regard to this letter. Rasmussen had heard through another party that Capehart was in financial trouble and thought it would be easy to make a deal of some kind with Capehart regarding the use of their record changers in a Zenith set.²⁶ There apparently is at least one example existing of a Capehart record changer in a Stratosphere (1000Z) cabinet.²⁷

In 1936, when Crosley presented the WLW 37-tube console, McDonald told his friend, Charles Iredell:

Regarding the clipping of the Crosley 37-tube set, I told Powel (Crosley) the first time I saw this I was with my assistant, Paul Bryant, who remarked "My God, Crosley has designed this set just too late. The only place it would fit in Chicago has been closed by the Police, The Everly Club." I don't think that set so well with Powel.²⁸

STRATOSPHERE SALES PERFORMANCE

Some time in 1936, the Zenith Sales Organization started a campaign to increase sales the 1000Z Stratosphere model. This is speculation on this author's part, but it was possible that

1. the inventory of packed Stratospheres on hand in finished goods had climbed to an intolerable level;
2. new models introduced by Zenith's competition slowed sales of the 1000Z;
3. McDonald may have felt that obsolescence of the Stratosphere was a concern with the imminent introduction of the motorized

Robot-Dial 1938 model in mid-year 1937. Previously, McDonald demanded action from the Sales Department on models that had growing inventories in finished goods, such as model 807, an upright table model from 1935, which at one time had 5,200 completed sets on hand in the factory.²⁹

Just before Christmas of 1936, McDonald wrote Rasmussen:

Mr. Rasmussen:

Let me see the sheet on how you have moved the Stratosphere since you sent the letter out and what each roadman has done or what each one has not done. I am speaking of the 25-tube job.³⁰

McDonald reiterated the following day:

Mr. Rasmussen:

You have not given me the data that I want on the 25-tube Stratosphere. I asked you for a copy of the letter you sent to each one of our road men giving them their quota, what their quota was, what each man has done for his territory, also including those who have done nothing.

Please get this data into my hands. Also advise me how many Stratospheres we had at the time the campaign was started and how many we have now, as well as how many were moved.³¹

The Stratosphere did not sell well to the public. It was more of an oddity—an object of wonder—and perhaps was used more effectively to *promote* the much lower priced, general Zenith model line between 1936 and 1938. Starting

BREUNER'S
Introduces
THE SUPERLATIVE NEW MUSICAL INSTRUMENT

The Stratosphere

BY **ZENITH**

25
TUBES

3
CONCERT SPEAKERS

Without any whisper reproduces music as heard

A SURPLUS OF POWER beyond anything you will ever need to bring in the most distant foreign stations, is only a detail of the Stratosphere story. When this astounding new instrument is tuned down to a whisper you begin to appreciate the modern scientific miracle of Zenith Micro-harmonic reception, which yields every vibration throughout the musical scale with perfect fidelity. Produced for those who are satisfied with nothing but the finest, the *Stratosphere* by Zenith is the most outstanding achievement in radio history. See it. Hear it. A new thrill awaits you.

BREUNER'S

Hi gate 4343 Oakland Broadway at 21st

Fig. 13. Advertisement from the Oakland Tribune, Wednesday, March 27, 1935.

with the 1936 Zenith black-dial model line, Zenith sales vastly expanded from previous model lines.

The Stratosphere was available both domestically and as an export. Like the Zenith Spanish Deluxe model of years earlier, purchasers of the Stratosphere included foreign rulers such as the Sultan of Morocco and the Emperor of French Indo-China.³²

E.H. Scott introduced the Philharmonic around April 1937. This thirty tube set employed twenty-four tubes in the main chassis and six tubes in the power supply. It also came with a 15" pedestal-style speaker having a built-in crossover network for optional high-frequency tweeters. The chassis and

speaker sold for \$272 to \$283.¹ It had an airplane type dial similar to those used in many Zenith models.

DEVELOPMENT OF THE BLACK MAGNAVISION DIAL

The Stratosphere was the first Black Magnavision dial Zenith. Subsequent models lines from 1936 through 1949 continued variations of this large dial. In January 1938, Gilbert E. Gustafson, Zenith's Chief Engineer, described

deal of thought. He finally said, "I have just thought of what's wrong with that dial—it isn't big enough—let's make one 5 inches in diameter." We pointed out to him the increased cost of a larger dial, and the difficulties of manufacture, but we drew up plans for a 5-inch dial, constructed the sample and a few days later had another meeting.

Commander McDonald again examined the sample carefully and after some thought said, "Well, I think that's a very nice dial, but it still isn't big enough—let's make one 6 inches in diameter."

This time he really did have an argument on his hands. Aside from the Engineering Department's objections as to the difficulty of design and cost, other points were brought out indicating that it was necessary to redesign a great number of cabinets, which had already been selected, rebuild all of our chassis jigs and crates, etc., but as you all know we had, that season, a 6-inch dial on our radio sets.

The American public liked it. Zenith sales almost tripled. The plant worked to capacity. The number of people employed was several times what it had been before. Plans for a bonus system were made.³⁴

This example again shows how much influence McDonald exercised in product design.

SUBSEQUENT ZENITH PRESTIGE SETS

In late 1935, Zenith began producing the sixteen-tube Stratosphere models. The 1601C and 1601P chassis used in these two models were both chrome plated and had a tone quality that rivaled

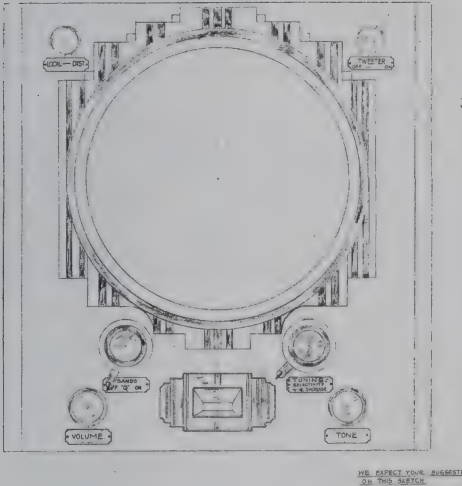


Fig. 14. The dial panel for the Stratosphere showing proposed control labels to be made of Pyrolene.³³ Note that the panel shows the two controls above the dial, added in time for the second release.

the 1936 Zenith dial development:

Three years ago, at about this time, we were having a meeting with the Management on details of the new line of radio sets for that year. My department had made samples of the 4-inch Airplane Dial as a suggestion for use on these receivers. Commander McDonald was present and I observed during the course of the meeting that he examined this dial sample very carefully several times, and apparently was giving it a great

that of the 1000Z. The 16A61 retailed for \$375. The 16A63 retailed for \$450. Both models had prices reduced in time for the 1937 season at \$295. Each of these models may be even scarcer than the 1000Z, since a total of 575 sets of chassis were built. The allocation is unknown, but it is possible that 250 per model of the domestic versions were built. The other 75 chassis were for export, or all-voltage capability.

For the 1938 line, Zenith produced a line of 15-tube single-chassis receivers and continued producing models having 15 tubes through the 1940 line. These were Robot Dial sets having Electric Tuning. The chassis for these models had gold hammer tone enamel finish.

For the 1942 line, Zenith produced two 22-tube radio-phonograph combinations, the 22H698 "Arlington" and the 22H699 "Concord." These both listed at \$650 and later the price was raised to \$695. These had a main receiver chassis and a power supply/audio amplifier chassis, built similarly to the three Stratosphere models. A total of 800 sets of the chassis were built to be allocated to these two models. Power consumption was 325 watts with a maximum audio output power of 50 watts, very much like the Stratosphere. Two 12" woofers and one 6" tweeter were employed. The chassis for these sets, however, were not chrome plated, but were painted the standard gold hammer toned finish like other Zenith console "Goliath" chassis. The cabinets were of bilateral design, like many other radio-phonograph combinations produced just before World War II.

PECULIARITIES OF THE STRATOSPHERE

The first version of the Stratosphere utilized four control-shaft axes, all below the dial. A subsequent upgrade consisting of the local-distance switch and the treble switch (which was a defeat switch for the horn tweeter) added above the dial gave the revised Stratosphere six control-shaft axes.

The dial scale of the 25-tube Stratosphere used at least two different variations in the logo lettering. One version used the traditional "lightning bolt" logo-type for both words "Zenith" and "Stratosphere." Another version used a variation of the Zenith logo, but the letters did not taper towards the end of the word. The word "Stratosphere" appeared in a fancy, tilted, cursive style. The cursive styled logo may have been limited to the 63 MHz "early" version.

The vast majority of the later or higher serial numbered sets in the series range to 45 MHz, instead of the 63 MHz on the earlier sets. Both versions are listed in Table 2.

Referring to the circuitry of the early 1000Z version, *Radio Today* stated in October 1935:

This 25-tube receiver is a custom-built job and was not produced in usual production manner, so that the likelihood of numerous service calls is not very great. Although not certain of exact figures, we believe that the production of this particular model was definitely limited. However, it is still significant to note that the grid circuit of only the first r-f. stage is tuned. The remainder of the tuned circuits in the r-f. system are in the plate circuits of the first and second r-f. tubes.

The highest frequency band in this receiver is covered with a separate coil, which is not a

part of the tapped detector coil in the receiver. The first r-f. stage is not used when covering the 4.7 to 15.3-meter band in the highest range. The input signal is fed from the antenna to the plate circuit of the 2nd r-f. tube. However, a portion of this band, as covered by the next range, namely, from 9.4 to 31.5 meters, is amplified by both r-f. amplifiers.³⁵

This also confirms the author's observation that the Stratosphere was custom-built. The Stratosphere in the author's collection tunes to 63.6 MHz and is an export version, even though it was one of the last ones built in the final release. There are at least two other examples of variances in the production runs of the Stratosphere: one unit has a chrome-plated power supply; another unit is an export version.[□] The radio frequency amplifier was overhauled in the revised version. The broadcast band uses both a preselector and a tuned RF stage. There are some 1st and 2nd AF stage changes between the two versions.

The 25-tube Stratosphere employed six dial glasses, one for each waveband with one set aside for the split-second scale. Lamps illuminated each glass from the dial's edge. Zenith etched each glass with the band and frequencies so that with the set energized, a color filter at the edge of each

dial glass determined the color of the intaglioed figures. The split-second band shown with a separate dial lamp continually while one of the five other lamps lit at a time depending on the band selected. With the set turned off, the etched areas are gray.

The lamps utilized by the 25-tube Stratosphere are also unique. Six special 110-volt tube-shaped elongated lamps were used, Zenith part #100-28. These lamps were rated at 15-watts and had candleabra screw bases. This circuit was tied directly to the 110-volt AC supply. The RF section was double-shielded in a black box mounted on top of the chassis. The individual coil assemblies were shielded within this box in individual cans.

The audio section was much larger than other, run-of-the-mill Zenith receivers. Eight 45 type audio power amplifiers were laid out in a parallel-push-pull configuration. Zenith's reason stated for designing it in this manner achieved a better balance in this stage by using several medium size power tubes rather than a pair of high-power tubes. The voltage requirements were greatly reduced using this configuration.

All Stratospheres had an upper and lower chassis. These chassis were chrome-plated, except for the lower 25-tube chassis, which was usually finished in black. The upper chassis was the receiver (C suffix) chassis, and the lower was

Dial Scale - Early

"Split-second" scale

535-1550 KHz

1.530-4.575 MHz

3.725-11.15 MHz

9.5-31.6 MHz

19.5-63.6 MHz

Color

white

green

orange

yellow

red

blue

Dial Scale - Late

"Split-second" scale

520-1500 KHz

1.45-4.2 MHz

3.7-10.0 MHz

8.5-23.0 MHz

18.0-45.0 MHz

Table 2: Zenith 1000Z Stratosphere Waveband Coverage and Dial Scale Color

the power supply (P suffix) chassis. The power amplifier was located on the lower chassis also. Zenith modified the coverage of the 25-tube Stratosphere in the second run, possibly due to poor performance or parasitic oscillation near 63 MHz.³⁷

VARIABLE I.F. BANDPASS

All three Stratospheres employed a variable IF bandwidth selectivity control. Zenith engineered the sets to have IF transformers with variable mechanical coupling, which, in turn, translated into variable bandwidth, or selectivity. Adjusting the variable selectivity control did not affect RF sensitivity of the receiver.³⁸

McDonald wrote Gustafson regarding a suggestion from a man in the field named Tidmarsh. He suggested installing the variable selectivity control on all Zenith models priced above \$125. Gustafson replied:

I want to say that this is easily possible, but in view of the poor acceptance we have had on the high fidelity control on the 25-tube set, I question the advisability of it. I would have done it long ago had it not been that we receive almost no comment on what I consider a very desirable feature. Everybody raves about the excellent low response, but only about one person out of ten seems to en-

OVER-ALL AUDIO RESPONSE

At 1000 K. C.

Variable Selectivity in Broad Position

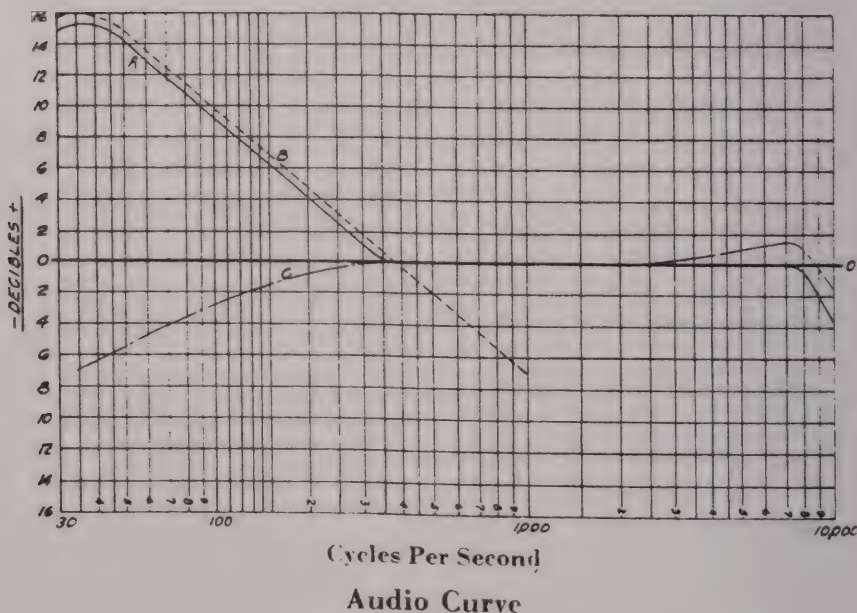
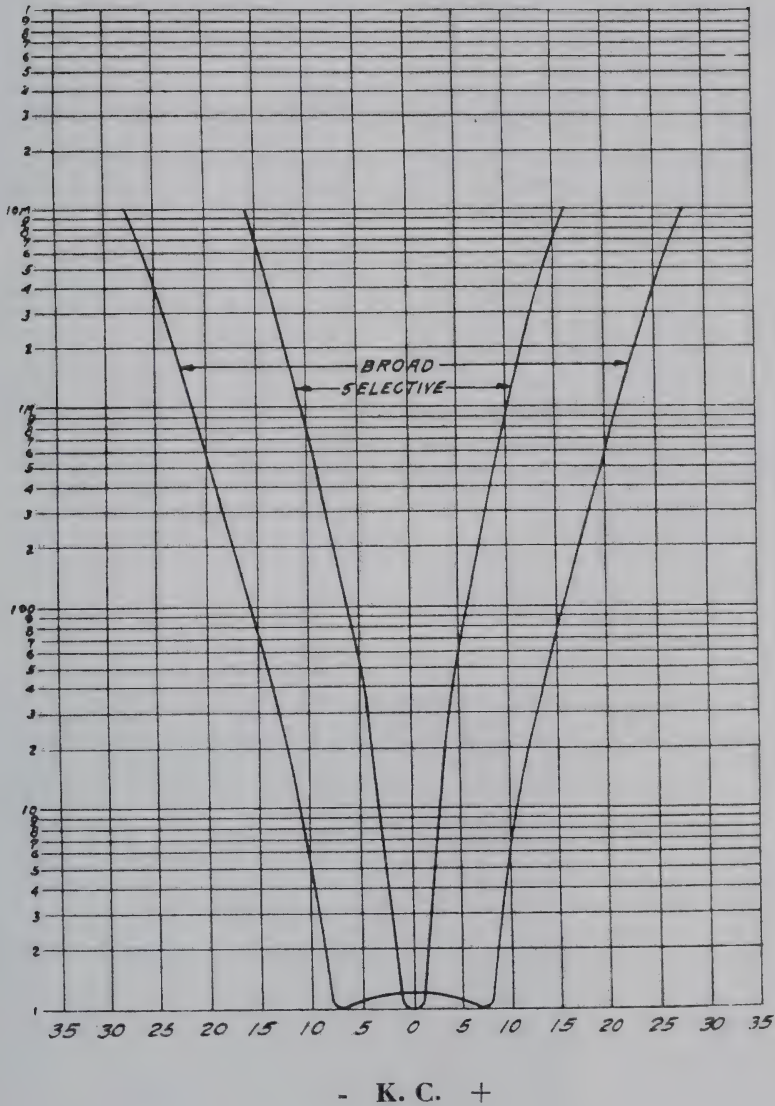


Fig. 15. Audio response of the 1000Z Stratosphere with the tone control set to three different positions: A=midrange; B=bass position, fully counter-clockwise; C=treble position, fully-clockwise.

OVER-ALL SELECTIVITY At 1000 K. C.



- K. C. +

Selectivity Curve

Fig. 16. Plot of the 1000Z Intermediate Frequency selectivity using the variable Bandwidth control set to both extremes

thuse about the increased high response.³⁹

The author finds this statement amazing, since the variable selectivity control has such a vast effect on the sound quality of received stations. Refer to the following graph. When the variable selectivity control is set to the "selective" position, the fidelity is poorest because the band-pass is narrow, but inter-station heterodyning is virtually eliminated due to the rejection of the adjacent channel stations of roughly 60 dB, based on 10 KHz channel spacing. This is a wonderful feature when listening to short wave stations, where inter-station heterodyning (the high pitched ringing) is commonplace. It is also useful when listening to weak stations that are adjacent to stronger stations on the radio dial.

With the variable selectivity set towards the "broad" position, maximum fidelity is achieved, since the side lobes containing much of the high-frequency audio are passed through the wider band-pass. This setting is desirable on strong or local stations, where the AVC or AGC voltage reduces the noise floor. This gives the high-fidelity reproduction that was intended by the designers of the Stratosphere (in the context of the 1930s amplitude-modulated stations). The broad setting will work poorly when trying to listen to weak stations that are adjacent to strong or local stations. This is because the band-pass covers roughly ± 7.5 KHz and the stronger station, being either 10 KHz above or below the desired station, will interfere greatly with the desired signal.

The serial numbers of this model range from 754001 through approximately 754350. The serial numbers listed in the *Zenith Service Manual, Volume 1*, page 287

(the first series of the 1000Z) are incorrect. The number should start with "754," not "174."

It is now believed by this author that a quantity of only 350 of these sets were released by Hugh Robertson, being that 250 were released by January 31, 1935 in two separate releases of 100 and 150 (that latter was amended from a release on January 28 of 100 units). Another release for an estimated 100 units came sometime well after April 20, 1935.

THE STRATOSPHERE CAT

Perhaps even more elusive than the Stratosphere is the sleek, art-moderne figurine of a sitting cat that was employed in advertising graphics of the 25-tube Stratosphere. It is believed that this was only a prop and that it was not supplied with the retail purchase of a Stratosphere. Note that the illustration shows the first version of the Stratosphere having four control-shaft axis and that the cat figurine is looking towards it right.

Little is known about the figurine, but there appears to have been several different versions of the cat produced in different sizes. The one pictured in Zenith advertising appears to be roughly 12" tall. The Catalina Pottery Company produced at least one version which was much smaller than the one in the Stratosphere. Another version was 17 5/8" tall and produced by William Bragdon in California. It was sold either through Gump's or Magnin's in California. Other versions had the cat looking towards its left instead of its right, both in pottery and in chalkware. One ceramic version is about 19 1/2" tall and is painted orange, much larger than the Stratosphere cat.

The author discovered a chalkware version (there is no opening in the base) recently in an antique

store that stood 14 1/2" tall. It is almond/cream colored; has airbrushed eyes and painted whiskers. It now stands prominently in a Stratosphere.

PRESENT-DAY STATUS OF THE STRATOSPHERE

Jim Clark, a radio collector and dealer, conducted research on the Stratosphere by creating the "Zenith Stratosphere Registry" in the early 1990s. Through the registry, he surveyed the field to register all known Stratospheres in the radio collecting community. He discovered that roughly 10% of the 1000Z sets produced were known to be in the hands of radio collectors as of January 1997.⁴⁰ It was not a scientific survey, since it is possible that others were in the hands of collectors but either they were missed in the canvassing or chose not to respond. A few others have "surfaced" since the survey was conducted.

The following is true for those sets documented in the Zenith

Stratosphere Registry:

- 36 units were documented.
- Some of the units have 25-cycle transformers installed.
- Seven of the documented units were missing cabinets.
- All of the units from the first release cover frequencies up to 63.6 MHz, while all but two of the subsequent releases (revised) groups cover up to 45 MHz.

The knowledge gained through that research raises questions regarding the legacy of the Stratosphere. Some questions that come to mind are:

1. How many sets were destroyed by fires, earthquakes, floods, severe weather, or poor storage?
2. How many were hastily put out at the curb or sent to the city landfill?
3. How many were converted

to liquor cabinets and the like?

4. How many are in the hands of radio or antique collectors, unknown to the general radio collecting community?
5. How many are still in the hands of heirs, whether or not they understand the set's significance?



Fig. 17. Chalkware cats similar to the prop used in Zenith advertising. The orange one on the right is actually pottery and is 18" tall. Author's collection.

One would hope that the answers are much higher in the last two questions rather than the first three. Being that this radio model was retailed for \$750, one would tend to think that few of them would have been summarily tossed—unless they were stored in a poor environment and the cosmetic condition degraded to the point that the layman surrendered. My guess is that many units are still in the hands of heirs.

The following two cases will make radio collectors wince, however:

1. One 1000Z set was recently rescued near St. Louis, Missouri. A fellow radio collector found both chassis and the two woofer-speakers at an estate auction. Through diligent investigation, he discovered that the cabinet was across the street from the auction site and was about to be disfigured by its owner who wanted to make a nice liquor cabinet out of it. Luckily, the collector was able to save the radio from permanent destruction!
2. A Zenith radio dealer located in Ottawa, Kansas, 50 miles southwest of Kansas City, closed his store in the early 1960s. The entire second floor of the downtown business was full of old radios, most likely trade-ins or ones deemed beyond economic repair. In an effort to sell or lease the building, the bank that owned the building hired some teenagers to clear its contents. I met one of the workers, who owned an antique store when I spoke with him in the early 1990s. He and I both cringed as he stated that he and the others

hauled many loads of radios to the city dump. The teenagers had somewhat of an informal contest, throwing the cathedral and tombstone styled table sets as far as they could to maximize the damage. Admittedly, he had no appreciation for antiques at the time.

The Stratosphere in the author's collection belonged to a physician who lived in Granite City, Illinois, a suburb of St. Louis (not to be confused with the "liquor cabinet" example listed above). It has two 25-cycle power transformers, which are much larger than the normal 60-cycle transformers usually found in the Stratosphere. A well-known radio collector from Missouri sold it to me in 1992.

EPILOGUE

The Zenith Stratosphere radio console is an extraordinary instrument. Although not popular with the pocketbook in the 1930s, it has achieved legendary status among vintage radio collectors and restorers. Of the tens of thousands of radio models produced since the birth of broadcasting, very, very few vintage radio sets, if any, sold today command as high a selling price as the Zenith 1000Z Stratosphere. Several factors seem to contribute to its gradual increase in value:

1. Its striking design—in Frank Johnson's cabinet, the dial, and the chassis.
2. Its rarity, since only approximately 350 were produced.
3. Its significance as being the pinnacle of Zenith household receivers.
4. Its significance as being the inaugural Big Black Dial Zenith.
5. General discussion among

collectors of radios and antiques, fueling the interest and enthusiasm for the model.

There are few radios as coveted as the Zenith Stratosphere. A major portal to its interest is that it is a Zenith, a very commonly encountered and desired radio brand among radio collectors, especially for floor model consoles.

I remember being told by a fellow collector about his encounter with a Stratosphere at an antique store in the Tulsa, Oklahoma area. It had a bargain basement price of \$1,000. He did not have the money with him at the time, but told the proprietor that he would be back in the morning with the cash. When he arrived the next morning, the set was gone. The moral of the story: don't leave the store until you own that rare antique. *When one acquires one of these revered, rare sets, it is truly an accomplishment.*

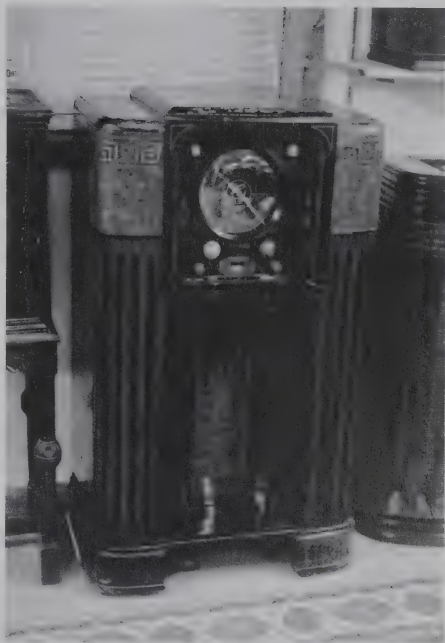


Fig. 18. Serial # 754328, unrestored condition. Photographed in 1992. Note the hazed finish on the pedestal. Also note the poor condition of the black lacquer finish on the trim and the missing finish on the right shoulder.



Fig. 19. The author with serial # 754328, restored all except for two knobs that have chipped-away finish.

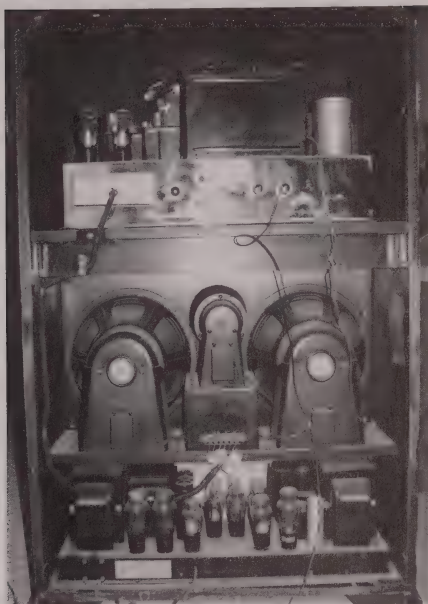


Fig. 20. Rear view of Serial # 754328 with the screened frame removed. This is probably the first Zenith model to have a tinted cabinet interior, which appears to be black on the 1000Z.



Fig. 21. Serial # 754328, restored condition. The original lacquer finish was left intact on almost all panels except for the top of the set, which had water damage and required veneer

replacement on the top center panel. The black-lacquer trimmed surfaces required removal of the finish using a razor blade, which were then re-lacquered. The upper section of the right side panel of the set also exhibited water damage. A 2" by 3" area 2/3 of the way towards the back edge of the cabinet, in the marquetry, required replacement of the Carpathian Elm burl veneer and 1/4" trim banding. After completing repair of the cabinet veneer, I applied one coat of lacquer tinted with orange aniline dye, followed by two more clear coats, followed by hand-rubbing using pumice, followed by rottenstone, in a medium of mineral oil on a pad.



Fig. 22. Close-up of the dial of serial number 754328. This unit was produced as an export model and employs 25 cycle transformers. Note the cursive "Stratosphere" logo, the split-second dial calibrated in hours/minutes, and the ornate pointer



Fig. 23. Close-up of the dial employed on most of the latter-produced units. Note the gold "Z" dial pointer; the re-calibrated waveband ranges, and the "Stratosphere" logo in the lightning bolt motif. The split-second scale changed from hours to minute markings also. Picture courtesy of David Wilson.

REFERENCE NOTES

- 1 Clark, Jim. *Jim Clark's E.H. Scott Radio Collectors Guide (1925-1946)*. Okemos, Michigan: Jim Clark Enterprises, 1995.
- 2 McDonald, E.F. Memo to Pressly, Tracey, Hassel, Klugh, and Robertson. December 11, 1933.
- 3 *US Patent Office Official Gazette*, September 11, 1934, p. 487.
- 4 McDonald, E.F. Memo to Robertson. September 14, 1934.
- 5 Anonymous. Zenith Radio Corporation Consolidated Balance Sheet dated November 30, 1934. This item was listed as: "Account #504, Deluxe Multitube Set." The only expense item costing more for that seven month period was the development of the Hudson auto radio for 1935 with a figure of \$8,572.
- 6 Stevens, Captain Albert W. "Exploring the Stratosphere." *National Geographic Magazine*, October 1934: 397-434.
- 7 Associated Press. "Woman Far in Sky." *The Kansas City Star* Oct. 23, 1934, page 1 & 3.
- 8 McDonald, E.F. Telegram text to Gustafson. September 25, 1934.
- 9 Gottlieb, Vivian. Honeywell Quality Inspector. A First Article Inspection (FAI) denotes a thorough inspection conducted to ensure that the configuration of a finished sample of the new product agrees with the Bill of Material (BOM) and engineering drawings before that unit or any subsequent units are shipped.
- 10 McDonald, E.F. Memo to Gustafson. December 12, 1934. A postscript added: "Phoned to Gustafson at Mt. Prospect 3:20 PM Wednesday 12-12."
- 11 Robertson, Hugh. Various Release authorizations. McDonald Files, 1935.
- 12 McDonald, E. F. Memo to Freese. January 2, 1935; McDonald, E. F. Memo to Gustafson. February 4, 1935; Gustafson, G. E. Memo to McDonald. February 6, 1935.
- 13 Iredell, Charles J. Letter to McDonald. February 1, 1935.
- 14 McDonald, E. F. Letter to Charles J. Iredell. February 4, 1935.
- 15 Burnet, R.D. Memo to Robertson, copies to McDonald, Tracey, Freese, and Ericksen. February 8, 1935. Report on J.A. White.
- 16 Ibid.
- 17 McDonald, E. F. Memo to Burnet. February 8, 1935. Included with the memo are several worksheets of Ray Burnet showing monthly sales and returns.
- 18 Robertson, Hugh. Weekly Report of Authorized Production – Shipments to Date – Orders on Hand and Balance to Sell. October 29, 1934 through April 20, 1935.
- 19 Robertson, Hugh. Weekly Report of Authorized Production – Shipments to Date – Orders on Hand and Balance to Sell. December 29, 1934. Robertson penciled in the cancellations "corrected to 1/4/35" with the "orders on hand" column changed from 119 to 46; the "sales to Date" column changed from 136 to 63.
- 20 Dorf, William C. "What's New in Radio." *Radio News*. April 1935:644.
- 21 Scott renamed the Imperial as the Scott Full Range High Fidelity Allwave after discovering that another radio manufacturer was already using the "Imperial" designation.

Zenith 1000Z Stratosphere

- 22 Gustafson, G.E. Memo to McDonald. April 26, 1935. The memo discussed problems that Mr. Gustafson noted in a sensitivity test on a 10-tube model at 9.75 meters. The sensitivity was poor: 200 to 300 μ V. He compared it to the 1000Z in the following paragraph: "However it occurred to me that the first release of Stratospheres had a range in the number 4 band of 10 to 30 meters and therefore I called McManamon, the final tester in Plant #3, to hook up one of these sets and listen for it. He reported that he could hear it [the station] very strong and could understand what was being said. The newer Stratospheres however have a limitation on the fourth band [8.5-20 MHz]. This range being 12 to 35 meters. Both the old and the new sets however have a 6 to 15 meter range but this range is very poor, the same as in the 10 tube sets. On this range the tubes do not oscillate and it is necessary to use the 2nd harmonic. This is one reason for the poor sensitivity."
- 23 McDonald, E.F. Memo to Gustafson. July 25, 1935.
- 24 McDonald, E.F. Memo to Gustafson. September 23, 1935.
- 25 McDonald, E.F. Memo to Robertson. January 28, 1935. This memo discussed items that J. Clarke Hagey indicated should be listed on the patent sticker or in literature.
- 26 Rasmussen, Jimmy. Memo to McDonald. July 3, 1936.
- 27 Zenith radio collector Frank Rasada encountered one years ago.
- 28 McDonald, E.F. Letter to Charles Iredell, Cincinnati, Ohio. December 12, 1936.
- 29 McDonald, E.F. Memo to Robertson. February 1, 1935. Only 44 of the model 807s were ordered in the week previous to 2/1/35. (Author's note: at that rate, it would take 118 weeks to sell the ones already produced.) There were still 1,410 on hand as of 9/14/35, well into the 1936 season, the first of the black-dial sets. As of April 20, 1935, 21,000 of the model 807 were authorized by releases.
- 30 McDonald, E. F. Memo to Rasmussen. December 22, 1936.
- 31 McDonald, E. F. Memo to Rasmussen. December 23, 1936.
- 32 Anonymous Article. Zenith Radio Log. "Your Fingerprint on the Other Side of the World" discusses certain models and where they are used around the world. July 1937:4.
- 33 Gustafson, G.E. Memo and attached drawing to McDonald, Robertson, Tracey, Freese, and Hefter. February 1, 1935. The scale of the drawing found by the authors was the actual size of the Stratosphere control panel. Attached to the memo was a sample of Pyrolene having a printed face. This material appears to be very similar to the 1932-1935 dial scales and Shadowmeter screens. Perhaps Gustafson was sounding this material for the revised version of the Stratosphere.
- 34 Gustafson, G. E., Chief Engineer, Zenith Radio Corporation. Zenith Radio Log, January 1938:2. Article illustrating the importance of product suggestions and loyalty bonus program.
- 35 Anonymous. Service Notes—Rider. "Zenith Stratosphere." October 1935:28.
- 36 Clark, Jim. Letter addressed to Stratosphere owners. "Serial Numbers of Documented 25-Tube Zenith Stratospheres." June 14, 1993.
- 37 Zenith collector and historian Dale Goodwin relayed this information to the author.
- 38 *Zenith Service Manual, volume 1*, p. 288. Theory of operation for model 1000Z Stratosphere.
- 39 Gustafson, Gilbert. Memo to McDonald. November 11, 1935
- 40 Clark, Jim. Letter addressed to Stratosphere owners. "Serial Numbers of Documented 25-Tube Zenith Stratospheres." January 10, 1997.

ABOUT THE AUTHOR

At the age of five, Martin Blankinship remembers his grandparents having a 1942 Zenith 7S657R console in their living room. On that set, he listened to such programming as DJ Johnny Dolan on WHB, Kansas City's powerhouse Top-40 station. When Martin was 11, the dial string broke on that radio so he asked his grandma if he could fix it. She said if he could fix it, he could have the radio. He did, and the monster was born...

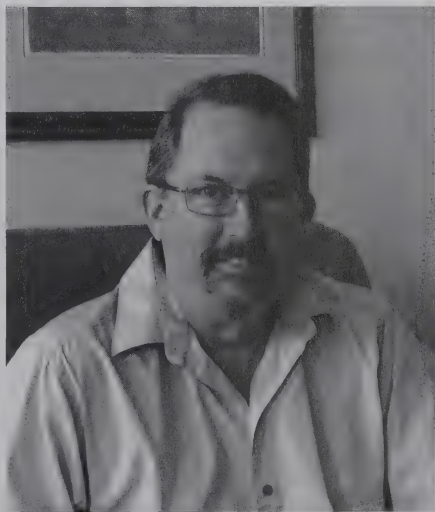
As a teenager, his radio interests grew in listening to vintage radio programs, such as *the Great Gildersleeve* and *X Minus One*. He collected these programs over nine years; amassing 1,600 hours of old time radio programs. A six-year hitch in the navy as a Fire Control Radar Technician would be serendipitous for what followed. After he got out of the service, while attending Washburn University, he just happened to catch Mike Adams' documentary: *The Radio Collector* on TV. Martin was then hooked. His electronics experience dovetailed perfectly with this hobby—or rather—obsession. He commenced collecting about any pre-World War II built household radio, but soon decided to specialize in one facet of collecting. In 1989—since his grandparents had given him their Zenith and also because he liked the styles of the earlier Zeniths—he began specializing in Zenith household sets and trading off other brands from his collection.

In 1990, through a tip, he found a large collection of Zenith radios in western Kansas belonging to legendary collector Dale Goodwin. Dale started collecting Zeniths back in the 1960s, before many of the sets were considered collectible. Martin bought the remainder

of Dale's Zenith collection. Filling up a 24' Ryder truck, he brought them home and they formed the core of his Zenith collection.

By 1994, he had over 500 Zeniths and helped Professors Bryant and Cones with photographs of sets in his collection used in the book: *Zenith Radio, the Early Years 1919-1935*. Martin found that he loved doing research on Zenith radios and the corporation. His collection peaked at about 800 Zeniths in 1999. Shortly thereafter, he got married to Rita, and slowed his collecting in exchange for the more intriguing research.

Martin was fortunate enough to help Harold Cones research Commander McDonald's corporate files, sealed shortly after his death in 1958. In those files, they found 30+ years of documents in 138 file drawers. This is certainly the 'mother lode' of information about McDonald and the Zenith Radio Corporation through 1957. Martin collaborated with Cones and Bryant on a two-volume set: *Zenith Radio, the Glory Years, 1936-1945*.



Martin Blankinship

AWA Review

The Earliest Heathkits and a Database for 1947 - 1956

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ABSTRACT

It is not possible to estimate the positive influence Heathkits had on generations of technical-minded individuals. Not only did Heath make devices available at much lower prices than commercially available units, the dimensions of understanding achieved through the assembly process they added were invaluable. Early on, employees were few; later there were hundreds or even thousands but with little recall of the past. This article is intended to add to that knowledge for historians and collectors. The first two years of kits, a time of rapid change, is treated in greater detail, and a database of the first ten years is provided in this article. Early changes, even if short lived, are of interest to historians and collectors. There were other kit makers, but only one Heathkit.

The purpose of this article is to provide historians and radio collectors with additional information on the earliest couple of years of Heathkits beyond that readily available at the present. A comprehensive listing of all Heathkit products for the first ten years is included to allow for a better understanding of the changes in kits sold from 1947 to 1956. The methods used to acquire the reference information are outlined in Heathkit Assignment of Model Numbers below. I felt that a better understanding of the early Heathkits is appreciated by discussing the factors affecting assembly manuals, model numbers, parts availability, and so forth. This is done in the following sections. Finally, photographs of a number of the specific early kits are included to help understand the design changes that are helpful for identification within a given kit, as well as early influences of parts availability such as surplus electronic sales. In the database tables I felt it important



Fig. 1. Edward Heath and his Baby Bullet airplane

to include in a brief description, information on the timeframe each kit was advertised, and price. In the Supplement, provision is made for a checklist to record whether or not one has a given item or manual. The alphanumeric table (Table III) is in the Supplement as a quick reference to aid in locating a given Heathkit if the model number is known.

It is unlikely that we fully appreciate the role of Heathkits in helping engineers, scientists, technicians and amateurs understand how things work and the relationship among components through the kit building process. My interest is in early Heathkits and their variations, a time in the history of the Heath Company when employees were few, only about 45 persons, later to number hundreds to thousands. Subsequent employees had little or no memory of the early days. This complicates the job of historians.

HEATHKIT HISTORY

The company was started in 1926 by Edward Heath, a former barnstormer, with the first products being airplane parts and kits, especially the Parasol airplane (Fig. 1). Heath died February 1, 1931 in a test flight crash. The company was purchased by Howard E. Anthony in 1935 and moved into surplus sales and electronic kits. Anthony was the driving force behind the development of the Heathkit electronic kits we know today (Fig. 2). He was in charge during the important early years of 1947 to 1950 and thereafter. He guided the company through the government surplus years of tubes and parts, to the era of higher production and more sophisticated instruments and assembly techniques. As described in a 1955 catalog (Ref. 1), he was "Mr. Heathkit." Tragically, he died in an

airplane crash on July 23, 1954. The 1955 catalog gave a detailed history of Anthony and should be read by anyone interested in the history of Heathkits. Additional history of Heathkit, as well as the era of Anthony, has been well documented by others, especially Chuck Penson (Ref. 2), Ron Grossman (Ref. 3), Terry Perdue (Ref. 4), and John Dilks (Ref. 5). After 45 years of operation, the maker of Heath electronic kits closed its doors in 1992, but continued with a line of educational products.



Fig. 2. Howard E. Anthony

MY OWN EXPERIENCES

My own venture into Heathkits started back in 1948 when I ordered a Heathkit battery operated All Wave Radio for \$8.75. That price doesn't sound like much, but I was born and raised on a farm in South Dakota and in 1948 we had no electricity, which was typical for the time in our rural area. I earned the \$8.75 trapping muskrats that I sold to Sears Roebuck in St. Louis for 75¢ to 95¢ each after the usual pelt preparation, which was a lot of work. I was pretty excited about getting the All Wave, but when it

arrived, I was depressed to find that they had sent the AC type. Included was a personal letter stating they were all out of the battery powered All Waves so they sent the AC type instead. To say I was disappointed was an understatement, and I sent the kit back. However, the personal letter was typical of Heathkit. My current efforts as described herein reveal that the K-2 All Wave battery type was advertised for only one month in *Radio News*, in July 1948. Today I wonder if they actually ever produced that battery version at all.

My next Heathkit was an M-1 Handitester I purchased in September 1949 for \$13.50. This was almost half the cost of the popular Triplett meters of the same type. It was a beautiful multimeter which was easy to assemble. Still lacking electricity, which we didn't get until the Federal REA came in the area in the 1950's, I heated the soldering iron with a blow torch, which every farmer and rancher had. I loved that meter. However, as an engineering student in 1952, I sold the M-1 for \$10.00 since I needed the money. I'm sure many reading this will appreciate doing such things in times of need. When my finances improved later in my career, I looked for years at flea markets and hamfests to find a Handitester replacement, but I was never successful. With the advent of eBay, I did find and buy one, which I still have. In fact, I bought quite a few on eBay until I gained control of myself.

I've lost track of how many Heathkits I built over the years. The last was an IO-10 oscilloscope many years ago. I never had the courage to take on the big stuff like their color TV kit. But I still remember ordering the Heathkits, anticipating the mail, unpacking the small packages of parts, assembling the instrument, and best

of all - when I turned on the device it worked!

EARLIEST YEARS – THE WAR SURPLUS ERA

When one examines the earliest Heathkits, such as the O-2 Oscilloscope, the V-1 VTVM and others, the kits used surplus metal vacuum tubes, surplus CRT's and, initially, oil filled capacitors (military grade). It also is apparent that as the availability of these parts dried up, the Heath Company switched to less expensive items, such as from toggle switches to slide switches or more available items such as from JAN military tubes to commercial glass tubes. Remarkably, Heath, as a rule, did not increase prices except for the K-1 All Wave Radio, which may have been underpriced at \$5.95 when introduced in May 1948.

Government surplus electronic sales ended March 1, 1948, according to a notice in *Radio News* for March 1948, page 191. Heathkits were priced about one-half of comparable commercial instruments. Early on, surplus sales undoubtedly played an important part in price, but later high volume enabled Heath to hold the line on prices. For a while, Heath probably also had a sufficient reserve of parts such as the surplus General Radio potentiometers used in IB-1 Impedance Bridges, first advertised starting in June 1948, as well as oscilloscopes and VTVM's.

CHANGES IN INSTRUCTION SHEETS AND MANUALS WITH TIME

In their first kits, such as the O-1 Oscilloscope, Heath made it clear you should have experience in building electronic apparatus. However, within a few months, although such knowledge helped,

one didn't have to know how to read a circuit diagram or schematic to build a Heathkit. Few things have been so well written in the electronic literature as the manuals produced by Heath. As it ends up, it was an iterative process starting with schematics and narrative description of what to do and then evolving into step-by-step instructions with numerous drawings to fulfill the reported Heathkit motto, "We will not let you fail."

This required the hiring of professional technical writers and developing internal techniques to verify the accuracy of the manuals before large-scale production. One of these techniques was to have an employee build a kit using the manual and then having the result evaluated by the engineering department and technical writers. The following briefly outlines manual and instruction sheet design and evolution (Fig. 3):

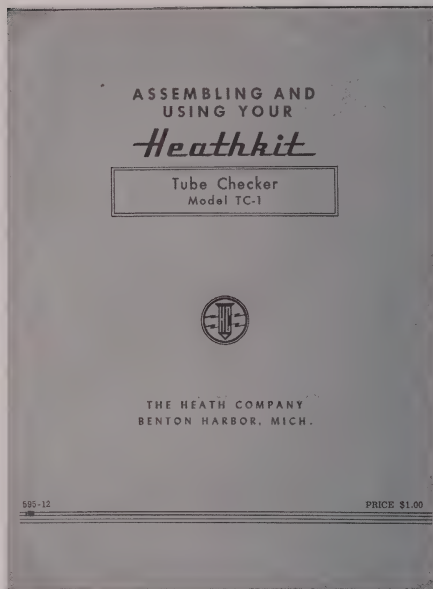
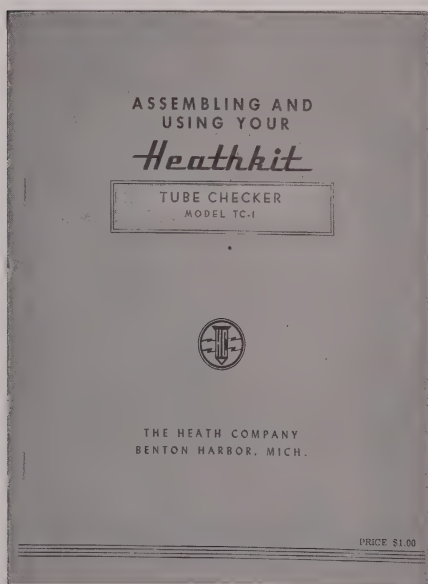


Fig. 3. Early Heathkit Manuals (A) Blue-green colored manual with pasted-on label (B) Blue-green colored manual with printed label (C) Yellow-colored assembly manual.

1) No step-by-step instruction: Schematics, simple line drawings of component placement, parts list, and an instruction sheet. Used for the O-1 and O-2 Oscilloscopes.

2) Blue-green colored assembly manuals with a pasted on paper label showing name and model number and some narrative, a schematic, parts list and step-by-

step instructions. Used for early V-1 VTVM, O-3 Oscilloscopes and some others.

3) As production levels increased, the paper label was replaced by blue-green manual covers printed directly with the name and model of the Heathkit.

4) Early yellow-colored assembly manuals.

5) Yellow-colored assembly manuals with large fold-out drawings. Sophisticated step-by-step instructions with sub-drawings. More detailed descriptions of how the kit worked and the use of the device appeared. Check off provisions were in the manual to help builders follow progress. Later this was the most common type used.

6) Still later, the yellow-colored assembly manuals had different artwork on the cover and, as the devices became more complex, multiple manuals appeared for a given kit.

A photograph of the external appearance of a given instrument did not appear in early manuals, but there were photographs of the interior. When external photographs did appear in the later manuals, they frequently were not changed as the model's appearance changed. Early parts lists did not use part numbers. Later, Heathkit numbers were assigned for every part.

CHANGES IN APPEARANCE — A CLUE TO AGE

Early kits set the stage for later devices with respect to color schemes, knobs, meters and so forth. The exception is the O-1 Oscilloscope that, in some respects, had a different panel layout from subsequent models. For all early Heathkits, it appears that most of the circuit designs were from existing manuals and handbooks, as well as reverse engineering of more

complex devices. Early Heathkits tended to have short production runs. Exceptions, like the TC-1 Tube Checker were advertised for many years (March 1949 to August 1953).

New Handles. The first Heathkit, the O-1, had a painted brass handle. An advertisement in the April 1948 *Radio News* shows four test equipment kits, all with the earliest khaki painted brass handle. These kits are the O-2, G-1, G-2, and V-1. None are identified by model number in the advertisements, but all had the model number on the actual instruments. Under "Tips and Comments" on page 3 of the March 1948 *Heath Flyer*, it is noted that there are new handles for Heathkits. It is stated that starting April 1, 1948, a new, modern polished aluminum handle is to be furnished with all Heathkits. In the May 1948 *Radio News*, on page 102, Heath advertised the new T-1 Signal Tracer and the C-1 Condenser Checker. Both the T-1 and the C-1 are shown with the new polished aluminum die cast handle. Even later, Heath cast the words "Heathkit Precision" in the aluminum handles. Eventually, Heath replaced these with molded plastic handles, probably as a cost-saving measure. The first oscilloscope with an aluminum handle was the O-3, first advertised in the July 1948 *Radio News*.

New Binding Posts and Knobs. The first Heath knobs were sculpted black Bakelite with some being plain black with straight sides. In 1952, Heath came out with new binding posts and black knobs with biconcave sides to allow finger tip operation (Fig. 4). A rectangular section opposite the pointer gives the knob "balance and proportion" according to Heath. The binding post (Fig. 4) was designed to accommodate

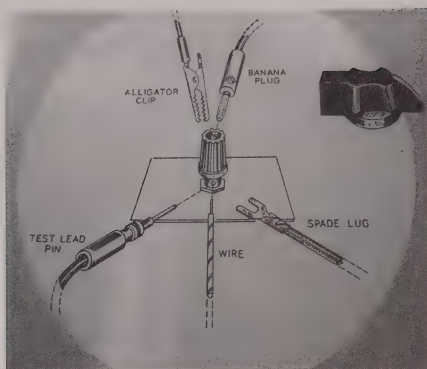


Fig. 4. New Binding Posts and Knobs (Heath Flyer for October 1952, page 10)

an alligator clip, banana plug, test lead pin, wire, and spade lug. The cap is plastic insulated on the outside with flutes for easy grip. As far as I can tell, this knob was first used on the V-5A VTVM.

Cases. Cases are of little value in determining age since all oscilloscopes in the O-Series used almost the same case. The G-1, C-1, T-1 and G-5 also used the same grey-colored case.

Panel Color. Except for the O-1, which may have been shades of black similar to the AT-1 Amateur Transmitter, all early Heathkit panels were beige with a surrounding red stripe, the so called "red-face." Later many models were changed to charcoal grey in color with no other physical changes. Still later, Heathkits had distinctive knobs, cases and colors.

HEATHKIT ASSIGNMENT OF MODEL NUMBERS

A number of problems arise in chronicling Heathkit models. This has to do with available source materials and peculiarities in model number assignments made by Heath. Since it represents the broadest source of Heath advertisements, I chose *Radio News*, which later became *Radio and*

Television News starting in September 1948, as a basic source for advertisements. Early on in 1947, the first Heath ads were not included every month. Later, they ran to 10 or 11 continuous pages of Heathkits. Problems with sources include:

1) Items sold but never advertised, such as the V-2A VTVM and the G-4 HF-AM Signal Generator.

2) Items advertised but possibly never sold, such as the V-3 Battery Powered VTVM.

3) Major change made but panel unchanged, such as the V-5 and V-5A VTVM. The V-5A uses a different tube and circuit, and the assembly manual says V-5A, but the panel still shows V-5.

4) Prototypes used in advertisements such as the TC-1 Type 1 Tube Checker.

5) A series may or may not be the same type of instrument. The V-Series (V-1, V-2, etc) are all vacuum tube voltmeters, whereas the G-Series are all different.

6) Heath *Flyers* were not identified as to month or year, only stating such as "Fall *Flyer*" for example.

7) Heath did not identify model numbers in early ads.

8) Heath dated kit schematic drawings the first year or so, and then stopped.

9) Heath would use the old version of the ad. For example, the January 1949 *Heath Flyer* has information on the new V-2 VTVM, but shows a picture of the V-1 VTVM (which has 5 ranges), whereas the V-2 has 6 ranges.

10) Sometimes an ad showed a reversed left to right image of the device.

Therefore, one cannot simply use common advertising sources, but must also consult schematics, assembly manuals, parts lists, and actual items in collections.

Most variations in a given model in the early years depended on two factors: (1) availability of surplus materials and (2) circuit improvements. Later model changes were due mainly to circuit changes or more sensitive components such as meters. For example, the V-2 VTVM used six, rather than five, ranges and regular flashlight batteries rather than the original and more expensive 3-volt B2FP Battery used in the V-1 VTVM.

THE HEATHKIT MULTI-YEAR DATABASE

With knowledge comes discrimination—the fundamental difference between the collector and the accumulator or hoarder. The collector or historian wants to know the origins, the differences, the variations and the quality issues. In general, the collector wants the best examples or museum quality, and they want to understand the reasoning behind changes. The accumulator wants all they can get, even if some are of poor quality. However, the accumulator often helps discover changes and variations that are important. Thus both collectors and accumulators help preserve history, especially those who are a little bit of both, like many of us.

From the printed documentation and observations of existing equipment, a table was created containing the following information: Model number, description, first advertised or probable date of introduction, date last advertised, and price.

Table I covers the 10 years of electronic kit manufacture and is chronological. Table II is the same data as an alphanumeric list that makes it easier to find a given Heathkit if you know the model number. Table I is at the end of this article, and Table II is intended

to be located on the AWA website.

SPECIFIC EARLIEST HEATHKITS

O-1 Oscilloscope. The first Heathkit was the O-1 Oscilloscope, which was first advertised in *Radio News* in the July 1947 issue in a small ad with few details. This was followed by an ad in the September 1947 issue of *Radio News*, showing the price at \$39.50 and a small picture of the O-1. A subsequent ad in the November 1947 *Radio News* on page 102 shows the O-1 with a display of the parts (Fig. 5). Many parts for the O-1 were war surplus, especially the 5BP1 cathode ray tube (CRT). It is said that Howard Anthony purchased a railroad car load of these at a very low price. The lowest price I found for a 5BP1 CRT was in a Lafayette Radio ad in the August 1948 *Radio News*, on page 114. They were selling the CRT for \$1.39, which the ad stated was “about one-tenth of the list price.” Apparently the demand for the O-1 was brisk. It is unknown how many were produced—perhaps only a few hundred. No O-1 Oscilloscopes have surfaced at this time in any museum or private collection.

We are not even sure about the O-1 panel color, but it did have a painted brass handle identical to those for later Heathkits such as the V-1 VTVM, the earliest G-1 Signal Generator, the earliest Sine and Square Wave Generator kit model G-2 (*Radio News*, June 1948, p. 86) and the O-2 Oscilloscope.

At the Dayton Hamfest on May 20, 2005, I chanced onto a packet of information on the O-1. The packet included three blueprint drawings: an original schematic dated September 8, 1947 (Fig. 6), two pictorial original assembly drawings (Figs. 7 and 8), a typed construction sheet, and a typed



Fig. 5. First Heathkit Advertisement Showing O-1 Oscilloscope and Parts (*Radio News*, November 1947, pg. 102).

parts list. Except for the schematic, all were undated.

A fourth sheet, also undated, that was included was titled simply "Heathkit 5" Oscilloscope" and included specifications and weight. Stapled to the left lower portion of

this sheet was a small black and white photograph (Fig. 9) of what we now call the O-1 Oscilloscope. The photograph is high quality and about 1 1/8" wide by 2 3/16" tall. The photograph depicts the earliest type handle (same as sub-

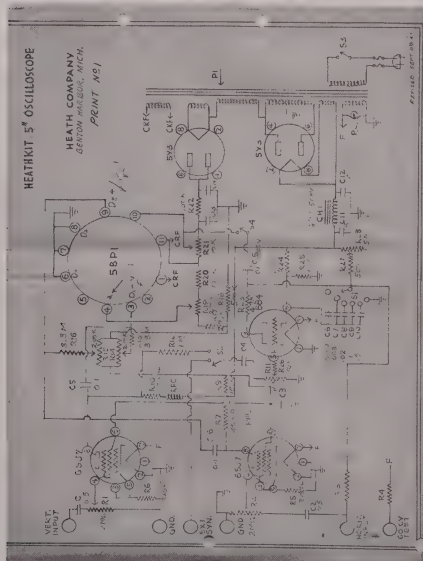


Fig. 6. Schematic of O-1 Oscilloscope Print No. 1.

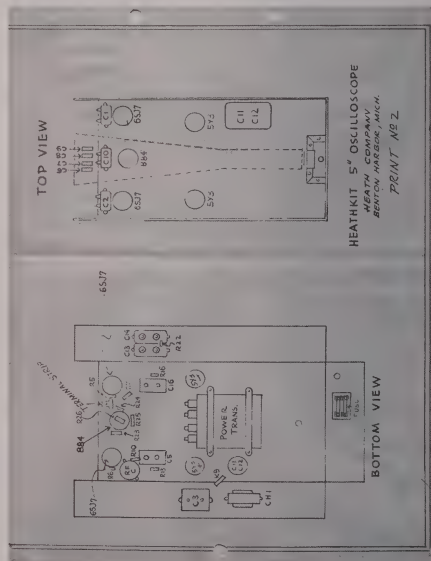


Fig. 7. Bottom and Top View Pictorial of O-1 Oscilloscope Print No. 2.

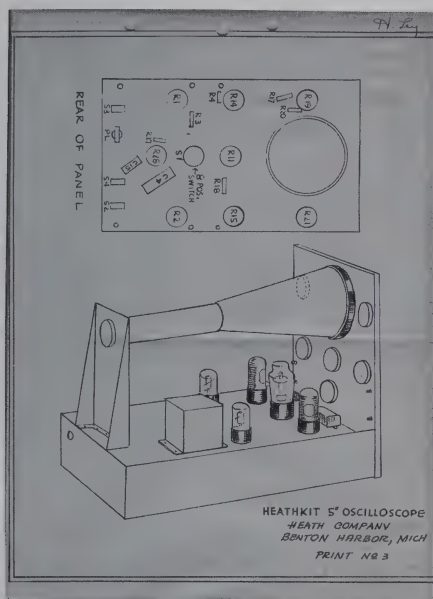


Fig. 8. Rear of Panel and Isometric Pictorial of O-1 Oscilloscope Print No. 3.

sequently used on the O-2).

The tube complement is one 5BP1 Cathode Ray Tube, 2x 6GSJ7 Amplifiers, 2 5Y3 Rectifiers and



Fig. 9. Copy of my O-1 Oscilloscope Photo.

and 884 triode gas thyatron, (same as 6Q5) for the Sweep Generator. The O-1 contains two 5 μ fd 600V Pyranol GE condensers and two 1000v oil-filled condensers. The handle was khaki painted brass. The step frequency switch had 6 contacts as shown in the September 8, 1947 blueprint schematic, one of which was a connection to chassis ground. The sweep frequency range was 15 Hz to 30 KHz. The copy of the O-1 photograph in the author's collection (Fig. 9) appears to have 7 switch positions.

Nowhere in any of the drawings, instructions or lists was the oscilloscope referred to as an O-1. Although it has some features similar to the O-2 and later oscilloscopes, the design is distinctive. It appears, in my opinion, to have a paint scheme somewhat in keeping with the AT-1 Amateur Transmitter, which was first advertised much later, in May 1953.

O-2 Oscilloscope. The O-2 Oscilloscope was advertised for five months, starting in February 1948 through June 1948. It had a khaki painted brass handle and toggle switches (Fig. 10). The external appearance of the O-2 was strikingly different from the O-1. It had a line around the outside of the panel, the so-called "red-face" design, and all binding posts were moved to the lower part of the panel. It had the same tube complement as the O-1. The sweep frequency control was changed to 5 positions. The assembly information was changed to one schematic blueprint (dated January 8, 1948), one layout drawing blueprint (dated January 8, 1948), one construction sheet (dated January 12, 1948), and one parts list (dated January 27, 1948). All of these are in the author's collection. A fuse block was added to the power input, as was a bypass



Fig. 10. O-2 Oscilloscope, note earlier handle

condenser. A number of circuit changes were also made to improve performance.

O-3 Oscilloscope. The O-3 Oscilloscope was advertised starting July 1948 for nine months and priced at \$39.50 (Fig. 11). This is the first Heathkit oscilloscope with the new polished aluminum handle. It was made in two versions. The first (Type 1) has toggle switches, and the second (Type 2) has slide switches. The Type 2 (Fig. 12) was probably produced at the end of the O-3 production run in March 1949.

The O-3 Oscilloscope has provisions on the front panel to switch the horizontal and vertical amplifiers directly to the CRT deflection plates (Fig. 12). For the first time, it had a connection at the rear of the oscilloscope chassis near the power cord to intensity modulate the CRT. The O-3 had a green assembly booklet with a pasted on paper label "Oscilloscope Model O-3."

A kit (Heathkit #315) to convert



Fig. 11. O-3 Oscilloscope, Type 1 Aluminum handle. Note "AMP. PLATES" on both gain controls.

the O-3 and O-4 oscilloscopes to the push-pull amplifiers circuit found in the O-5 was made available for \$12.50 in September 1949. The O-4 Oscilloscope was the first to use electrolytic capacitors in its filter circuit.

V-1 VTVM. The V-1 VTVM was the second Heathkit and was advertised in *Radio News* starting in December 1947, continuing for 16 months. The Heathkit V-1 VTVM uses a balanced bridge type circuit using two triode sections of a 6SN7 tube. Its 11 megohm input resistance prevents loading



Fig. 12. O-3 Oscilloscope, Type 2 Slide switches



Fig. 13. V-1 VTVM, Type 1, 5 ranges, toggle

of circuits under test. The meter is a 500 microampere movement, and the circuit uses 1% precision resistors. The ohmmeter measures one tenth of an ohm to one billion ohms. It came in three types, only two of which were advertised. The Type 1 has the khaki painted brass handle, a toggle on-off switch and 5 ranges. It was advertised December 1947 through June 1948 (Fig. 13). The Type 2 had a polished aluminum handle and a longer bat-handle toggle switch on most. The Type 2 was advertised for nine months, starting in July 1948. The Type 3 was like the Type 2 except it has a slide on-off switch (Fig. 14). I believe it was produced at the end of the V-1 production run, probably in March 1949. It was never advertised but is in my

collection and that of Jay Whipple, Jr. The V-1 was AC powered and used a Type B2FP 3-volt battery (no longer available) mounted on the chassis. A picture of the interior of a V-1 VTVM Type 2 is shown on page 2 of the June 1948 *Heath Flyer*. This view shows the type B2FP 3-volt battery used only in the V-1's mounted on the chassis.

V-2 and V-2A VTVMs. The V-2 VTVM appears similar to the V-1 Type 3 except it has 6 ranges. It is AC powered, like all V-Series VTVM's except the V-3. The V-2 used 2 D-size flashlight batteries mounted on the back of the case for the ohms circuit. It was advertised April 1949 through November 1949 (Fig. 15). On the first page of the January 1949 *Flyer*, Heath states that there are no yearly models, but models



Fig. 14. V-1 VTVM, Type 3, Slide on-off switch, has polished aluminum handle.

“change as improvements are made.” In the same *Flyer*, Heath illustrates the rationale behind the development of the V-2. It included a special battery tray using two flashlight D cells for the ohm meter, thus eliminating the special and expensive B2FP 3-volt battery. Savings enabled the purchase of two additional precision resistors, allowing the addition of a sixth range, a 10 v.a.c. and v.d.c. range and an R x 10 range, giving a total of 24 ranges. The meter was changed from 500 μ a to 200 μ a, increasing the sensitivity. The early photographs announcing the new V-2 show the old V-1 Type 2 (see Tables) with 5 ranges. This is not unusual since the art department and marketing were sometimes out of sync, or possibly Heath sought to save money by reusing artwork.

A V-2A version was made probably in November 1949, but it was never advertised. It had a larger meter than the V-2 (Fig. 15). The V-2A was replaced by the V-4 (with a larger meter) starting in December 1949 at the same \$24.50 price.

V-3 VTVM. The V-3 VTVM was battery powered and was advertised starting in March 1949 for three consecutive months (Fig. 16). It is interesting to note that the V-3 was first advertised one month prior to the V-2. The V-3 was to sell for \$34.50. No V-3 has

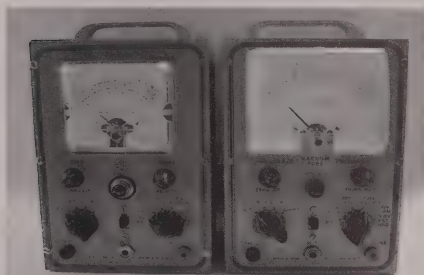


Fig. 15. V-2 VTVM 6 Ranges and V-2A with Larger Meter. (J. Whipple, Jr. collection)

surfaced in any collection to my knowledge, however the fact that it was advertised for three months suggests it was produced and sold.

G-1 Signal Generator. The G-1 Signal Generator was introduced in January 1948, just one month after the V-1 VTVM. This Heathkit signal generator provides fundamentals from 150 kHz to 30 megahertz with good harmonics to over 100 megahertz. The instru-

New Heathkit

BATTERY OPERATED VACUUM TUBE

VOLTMETER KIT



The famous Heathkit VTVM now in battery operated type. Use it anywhere — carry it out for work on auto radios — aircraft — boats — any place where 110 V. house current is not available — instant warmup — turn the switch and it's ready to operate. Same quality features; six linear D.C. ranges 0-3 V.-10V.-30V.-100V.-300V.-1000V. High voltage extended to 10,000 Volts with probe listed below. Large 200 microampere meter with shatterproof plastic face. Ohmmeter measures from 1/10 ohm to one billion ohms with internal battery. 11 megohm input resistance on DC. AC is copper oxide rectifier type with ranges as above except no 5 Volt range. Complete with all parts, cabinet, 2 color panel, tubes, batteries, test prods and detailed instruction manual.

\$34.50

SHIPPING WT. 12 LBS.

Nothing ELSE TO BUY

Fig. 16. V-3 Battery Powered VTVM (Radio News, March 1949, pg. 73)

ment produces 400 Hz audio as well. The G-1 uses a 6SN7 RF oscillator and amplifier and is transformer operated. Most of these G-1's work when found because of the use of oil filled capacitors and other war surplus parts. It was produced in three types (Type 1 in Fig. 17). See Table I. Unlike the V-Series where each is a VTVM, each member of the G-Series is a different kind of instrument except for the G-5 which is a Model G-1 with a vernier main control and a few circuit changes.

G-2 Sine and Square Wave Audio Generator. Advertised as a companion instrument to the Heathkit Oscilloscope, the G-2 Sine and Square Wave Audio Generator covers 20 to 20,000 Hz. The instrument uses 5 tubes, a 6SJ7 and 6K6 in the oscillator circuit, a 6SL7 square wave clipper, a 6S

cathode follower output and a 5Y3 as the rectifier for the transformer power supply. The cabinet is grey crackle painted with a "red-face" panel that matches other Heathkit instruments (Fig. 18). The G-2 was produced in three types. See Table I.

G-3 Sweep Generator. The G-3 Sweep Generator was first advertised October 1948 through March 1949 (Fig. 19) for \$24.50. It covers 2 megahertz to 226 megahertz either RF or FM with a variable sweep width from 0 to approximately 10 megahertz. It was replaced by the TS-1 TV Alignment

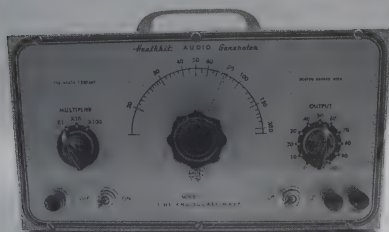


Fig. 18. G-2 Sine and Square Wave Audio Generator, Type 2, Toggle Switch



Fig. 19. G-3 Sweep Signal Generator

Generator in April 1949.

G-4 High Frequency AM Signal Generator. Thought by some to not exist since it was never advertised, I obtained a G-4 from eBay on September 21, 2003 (Fig. 20). I do not know the original Heathkit selling price, but I was, surprisingly, able to purchase a copy of the manual from a company online on April 11, 2009. The schematic is dated April 1, 1949.

G-5 Signal Generator. The G-5 Signal Generator is very similar to the G-1 Signal Generator



Fig. 17. G-1 Signal Generator, Type 1. Has Earliest Handle.



Fig. 20. G-4 HF-AM Signal Generator

except it has some circuit changes and the main tuning dial is a vernier, thus facilitating adjustment. It was the last of the G-Series and was advertised September 1949 through August 1950 for \$19.50. It was replaced by the SG-6 Signal Generator in September 1950 (see Table I).

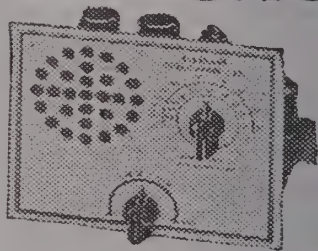
K-1 All Wave and K-2 All Wave Radios. Heathkit's first radio was a 3-tube All Wave Radio Kit first advertised in *Radio News* in May 1948 for \$5.95 with a speaker to the left (Fig. 21). The price was increased in June 1948 to \$8.75. A 2-tube battery version was introduced at the same time which was advertised in May 1948 and June 1948 at the same price with the same price increase as the AC version. The All Wave was not advertised in *Radio News* after June 1948. Some sources indicate that this was model K-1. Model HS-30 headphones were advertised May 1948 to December 1949 for \$1.00. A 2.5" PM speaker was optional and was advertised for this and the later K-2 All Wave from May 1948 to December 1949

HEATHKIT 3-TUBE ALL-WAVE RADIO

110-volt AC operation

An ideal way to learn radio. This kit is complete ready to assemble, with tubes and all other parts. Operates from AC. Simple, clear detailed instructions make this a good radio training course. Covers regular broadcasts and short wave bands. Plug-in coils. Regenerative circuit. Operates loud speaker. Battery model for use where no AC house current is available. Add postage for 3 lbs.

\$5.95



Heathkit Beginners' Radio 110-volt type.....	\$5.95
Heathkit Beginners' Radio, battery type (2 tubes, no rectifiers).....	\$5.95
Headphones for either type HS 30 per set.	\$1.00
2 1/2" permanent magnet loudspeaker for either type	\$1.95
Batteries, complete kit for battery type set....	\$3.25

Fig. 21. K-1 All Wave Radio (*Radio News*, May 1948, pg. 103)

for \$1.95. To my knowledge, no K-1 All Wave, either AC or battery type has survived. Since the K-1 was advertised only two months, there is some question as to whether it was actually produced.

The Heathkit K-2 All Wave is another matter. These survive in my collection (Fig. 22) and at least two others. The tube complement of my K-2 is one VT-169 (12C8) and two VT-134 (12A6) JAN war surplus tubes. The front panel is 6" by 4 5/8", and the set is 4 5/8" deep. The hole for the speaker grill is 2 1/8" in diameter. An obvious difference between the K-1 and the K-2 All Waves is that the speaker is on the right side and has a provision for a grill on the K-2 whereas it has 29 perforations instead of a hole on the K-1. Although the speaker itself was an option at \$1.95, all of the K-2's that I have seen have a speaker in place. Fur-

ther, some of the K-2's, identified by a speaker on the right, have K-2 written on the panel while others do not. The K-2 came with two coils housed within regular bakelite octal tube sockets, one for the broadcast band and one for short wave (1500 Kc to 6000 Kc). The coil with the built up winding is the broadcast band. The coil with the flat wider winding is the short wave coil. The K-2 All Wave Radio was advertised in *Radio News* from July 1948 through December 1949. A 2-tube battery version was also advertised but only for one month, in July 1948. To my knowledge, none of these have survived. In fact, this may have been the radio I ordered as a high school student and which never arrived as described earlier.

Several accessories made available for the K-2 All Wave were also for the K-1 All Wave, such as the 2.5



Fig. 22. K-2 All Wave. Note case, broadcast and short wave coils, war surplus tubes.

inch PM speaker, the HS-30 headphones, the Battery Set for \$3.25 advertised May 1948 through July 1948 and the mahogany cabinet advertised January 1949 through December 1949 for \$2.95. This cabinet may have fit both the K-1 and K-2, but was advertised after the K-1 was discontinued.

Of special interest is a set of accessory coils for the K-2 advertised only in the November 1948 *Heath Flyer* (Fig. 23) for 90¢ each. One coil was a long wave coil for 200 to 500 Kc and the other was a short wave coil for 6000 to 21,000 Kc. I have never seen either coil.

Based on a K-2 All Wave in the collection of Jay Whipple, Jr., later versions, or perhaps the last version, of the K-2 had a different tube complement of glass tubes (two 1626s and one 12A6) and a slightly higher front panel, 5 1/4 inches rather than 4 5/8 inches. This was probably done to accommodate the taller glass tubes. Also, this K-2 had a plastic dial pointer with an acorn style control knob (part no. V48) similar to that




Fig. 24. Probable Last Version of K-2 with vernier tuning. Jay Whipple, Jr. collection.

used in earlier Heathkit VTVM's (Fig. 24). This was coupled to a variable condenser with a vernier drive similar in principle to that used in the G-5 Signal Generator first advertised in the September 1949 *Radio News*. This vernier planetary drive system allowed for much better station selection, especially on short waves. Jay Whipple, Jr.'s K-2 manual states:

"Do not allow set to whistle as this interferes with neighbors radios. If trouble is experienced, consult your local radio service man and have him assist you in

NEW CABINET
Beautifies



Cabinet
EXTRA

\$8.75

ACCESSORIES FOR RADIO KIT

Mahogany Cabinet.....	\$2.95
Long Wave Coil 200-500 Kc.....	.90
Short Wave Coil 6,000-21,000 Kc.....	.90
2 1/2" PM Speaker.....	1.95
Headphones.....	1.00

Heathkit
3 TUBE ... ALL WAVE
RADIO KIT

This attractive mahogany cabinet gives the finishing touches to the excellent little receiver hundreds of boys received during the holidays.

Two new coils are available to extend the ranges. A long wave coil 200-500 Kc. covering aircraft and coastguard stations and a short wave coil covering 6,000-21,000 Kc.

The Radio Kit is a favorite for training purposes, boys just learning radio, etc. It is 110V 60 cycle transformer operated—comes complete with 3 tubes, all parts and complete instructions for assembly. It operates a loud speaker (extra) and is supplied with coils covering 550 Kc. to 6,000 Kc. which includes broadcast, police, aircraft, marine, foreign and amateur stations.

Shipping Wt. 3 lbs.

Fig. 23. Photo of Ad with K-2 All Wave Accessory Coils (Heath Flyer November 1948, pg. 6 or Heath Flyer, January 1949, pg. 1)

checking the wiring.”

This whistle of course was due to the regenerative circuit used in these radios. As one can see, this “contact your service man” evolved into better assembly manuals and a Heath policy of allowing builders to send in kits for repair, as well as an active approach of answering kit building questions.

T-1 Signal Tracer. The first Heathkit Signal Tracer was the model T-1 (Fig. 25). It was first advertised in May 1948 for 10 months at \$19.50. This had a polished aluminum handle and, like all others up to this time, was a “red-face.” This signal tracer uses an IN34 Crystal Diode probe that allows the input signal to be traced from antenna to speaker. The kit contains 3 tubes, a power transformer, and a 4” PM speaker.



Fig. 25. T-1 Signal Tracer

The size is 9” by 6” by 4 3/4”. Intended for use in a radio service shop, this was replaced by the T-2 Signal Tracer in April 1949.

IB-1 Impedance Bridge. The Heathkit IB-1 Impedance Bridge was first advertised in *Radio News* in June 1948 and last advertised August 1953. The bridge is a conventional 4-arm impedance bridge that is self-contained with its own 1000 Hz tone source. The bridge is direct reading over a wide range of resistance, capacitance, dissipation factor, inductance, and

storage factor. It has a built-in 200 μ a (100-0-100) galvanometer for resistance measurements and headphones for a-c measurements of capacitance and inductance. The layout and appearance was a virtual copy of the General Radio 650-A Impedance Bridge that sold in 1956 for \$270.00 (Reference 4, and Fig. 26). The General Radio 650-A was powered by four No. 6 Dry Cells in the top end of the

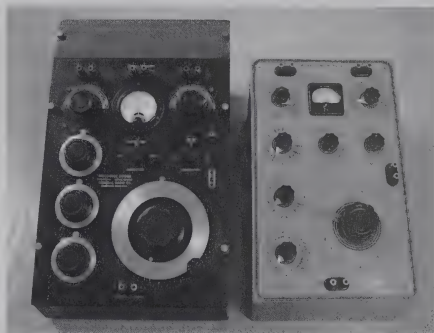


Fig. 26. IB-1 with General Radio 630-A. The IB-1 has 10-0 main dial and C-R-L below the main dial and multiplier switch.

cabinet. The Heathkit IB-1 was powered by one 6-volt Lantern Battery strapped inside the sloped birch cabinet.

The Heathkit uses 1/2% precision resistors, precision potentiometers made by General Radio or The Muter Company, and a General Radio microphone hummer to produce the 1000 Hz tone.

Three versions of the IB-1 were produced. The earliest version, the IB-1 (Fig. 26) has a main dial calibrated 10-0 and C-R-L printed on the panel in two places, below the main dial and below the multiplier switch and a non-linear potentiometer by The Muter Company. The IB-1A (Fig. 27) does not have IB-1A on the panel but can be identified by the main dial being calibrated 0-10 and L-R-C printed on the panel. The



Fig. 27. IB-1A 0-10 main dial and L-R-C below main dial and the multiplier switch.

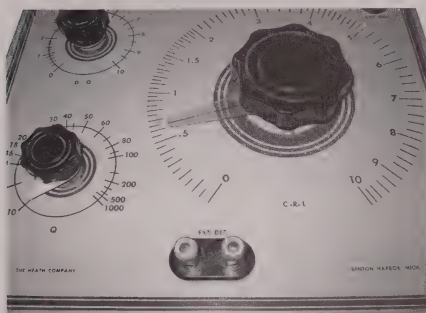


Fig. 28. IB-1B 0-10 main dial and C-R-L below main dial and multiplier switch.

non-linear potentiometer is by the General Radio Company. The third version, the IB-1B (Fig. 28), has IB-1B printed on the panel. The main dial is calibrated 0-10, and the panel shows C-R-L. The non-linear potentiometer was by The Muter Company. I believe all these versions were related to the type of non-linear main precision potentiometer available, probably from the surplus market.

C-1 Condenser Checker.

This was the first Heathkit with a magic eye indicator. In addition to checking paper, mica and electrolytic condensers, it will measure resistance. The schematic and assembly manual are dated June 22, 1948. In the manual, Heath

offered to adjust any C-1 against a General Radio 1% standard for \$3.00 plus shipping. Heath would also check and put into operating condition any C-1 for \$3.00 plus parts. The C-1 Condenser Checker came in two versions. The first or Type 1 (Fig. 29), had a toggle switch and was available September 1948 through March 1949 for

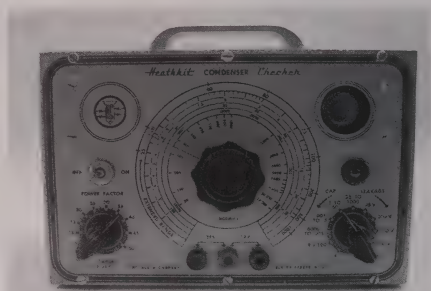


Fig. 29. C-1 Condenser Checker, Type 1. Toggle on-off switch.

\$19.50. The Type 2 used a slide switch and was advertised from April through December 1949 for the same price. Thus the C-1 Condenser Checker was advertised for 16 months.

S-1 Electronic Switch. The S-1 Electronic Switch came in two versions, Type 1 with toggle switches advertised September through November 1948 and Type 2 with slide switches advertised December 1948 through March 1950 (Fig. 30). The device is intended to display two signals at once on an oscilloscope screen. Each signal trace is controlled independently, and the position of the trace may be varied. For example, the input and output traces of an amplifier may be observed one over the other illustrating any changes occurring in the amplifier. The S-1 was priced at \$34.50.

BE-1 Battery Eliminator.

The BE-1 Battery Eliminator (Fig. 31) produces 10 amperes over a



Fig. 30. S-1 Electronic Switch, Type 2. Slide switch.

range of 5 to 7 1/2 volts. It has a heavy choke and a 4000 µfd electrolytic filter. It was used mainly for automobile radio servicing and battery charging. The heavy duty output terminals each have molded rubber caps that are frequently missing. It was advertised March 1946 through August 1950 and was priced at \$22.50. It was replaced by the BE-1A in August 1950.

TC-1 Tube Checker. The TC-1 Tube Checker was very popular and was first advertised in March 1949 for \$29.50. Based on my study of numerous TC-1's, it came in five types. Type 1, which was advertised for three months starting March 1949, may have been



Fig. 31. BE-1 Battery Eliminator

a prototype (Fig. 32). This TC-1 had double rollers (two rollers on the right side) rather than the one roller used in all subsequent advertisements. A Type 1 has not been found.

The TC-1 did not have an illuminated roll chart, but an update kit to upgrade to the TC-2 was later available. Multiple sockets were on the front panel with a blank socket to allow user customization. A rheostat compensated for line voltage changes. This control does not work very well today since present line voltage is 120 volts AC versus 110 volts AC in the 1940's. In subsequent years, roll chart updates

Nothing ELSE TO BUY
Only \$29.50

**Heathkit
TUBE CHECKER KIT**

Features

1. Measures each element individually.
2. Has gear driven roller chart.
3. Has lever switching for speed.
4. Complete range of filament voltages.
5. Checks every tube element.
6. Uses latest type lever switches.
7. Uses beautiful shatterproof full view meter.
8. Large size 11"x14"x4" complete.

Check the features and you will realize that this Heathkit has all the features you want. Speed — simplicity — beauty — protection against obsolescence. The most modern type of tester — measures each element — beautiful Bad-Good scale, high quality meter — the best of parts — rugged oversize 110 V. 60 cycle power transformer — finest of Mallory switches — Centralab controls — quality wood cabinet — complete set of sockets for all type tubes including blank spare for future types — fast action gear set of sockets for all type tubes to quickly locate and set up any type tube. Simplified driving roller chart uses brass gears to quickly locate and set up any type tube. Short and switching cuts necessary time to minimum and saves valuable service time. The Heathkit open element check. No matter what arrangement of tube elements, the Heathkit flexible switching arrangement easily handles it. Order your Heathkit Tube Checker today. See for yourself that Heath again saves you 2/3 and yet retains all the quality — this tube checker will pay for itself in a few weeks — better build it now. Complete with detail instructions — all parts — cabinet — roller chart — ready to wire up and operate.

SHIPPING
WT. 15 LBS.

Fig. 32. TC-1 Tube Tester, Type 1 Double Rollers (Radio News March 1949, pg. 73)

and update pamphlets for settings were made available.

I believe the changes in the TC-1 were all made in the first month or so, with the exception of Type 5, and were based mainly on the type of filament control switch used which may have been war surplus. One could ask, why put such emphasis on a switch? This is because this switch is reflected in panel changes, circuit changes, and the presence of an “off” on the panel. To a collector, these identify the earliest instruments and are very important.

The TC-1 Type 2 has a 15 position filament switch with an “off” position (Fig. 33). It also has the Heathkit logo (the letters HC in a circle) below the meter. The Type 3 has the same panel as the Type 2 but has a 14 position switch that will not go to the “off” position. The Type 4 has no “off” position

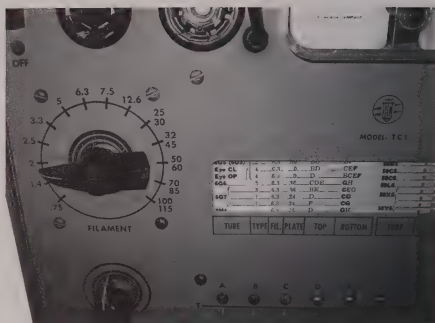


Fig. 34. TC-1 Tube Tester, Type 4, No “off,” with Logo

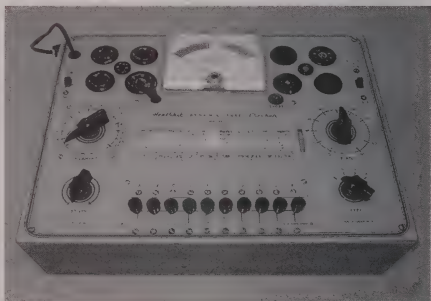


Fig. 35. TC-1 Tube Tester, Type 5, No Logo and Larger Meter



Fig. 33. TC-1 Tube Tester, Type 2, 15 Position with “off” (see text)

on the panel but still has a Heathkit logo (Fig. 34). The Type 5 has no logo and has a larger meter (Fig. 35) and was advertised from November 1952 through August 1953. It was replaced by the TC-2 in September 1953, still at \$29.50.

TS-1 TV Alignment Generator. The TS-1 TV Alignment Generator (Fig. 36) was a major departure from the previous G-3 Signal Generator. The frequency of the television signal was varied by a clever circuit using a permanent magnet audio speaker to mechan-



Fig. 36. TS-1 TV Alignment Generator

cally vary a tuned circuit. The TS-1 was advertised for nine months starting in April 1949 and sold for \$39.50. It was replaced by the TS-1A in January 1950.

M-1 Handitester. The M-1 Handitester was the first multimeter made by Heathkit, and the first Heathkit I purchased, in 1949. This is a beautiful instrument (Fig. 37) using precision resistors and an Assembly Products meter. The black Bakelite case was also used in several later Heathkits, such as the BT-1 Battery Tester and the CR-1 Crystal Radio. As time went by, the No. M-36 29 ohm resistor in the ohms circuit would drift or burn out. This resistor, when open, disabled the "Lo" ohms circuit. The earliest M-1's had a wire wound 29 ohm resistor and did not have this problem. The M-1 was

introduced in September 1949 for \$13.50, as compared to the Triplet Model 666-R at \$24.50 (*Radio-Electronics*, October 1949). It was produced for many years. A larger multimeter, the MM-1 was introduced in September 1953.

CONCLUSION

This documentation of Heathkits is intended to provide additional data for those interested in the history of radio. These data are based on advertised sources and direct observation of completed kits, assembly manuals, and instruction sheets. Society tracks and values accomplishments of artists, but we do less well with technology development including the history of communications. Heathkits have helped us understand the way things work and how things are put together. This has helped us get to where we are today. We have cell phones, computers, and flat screen TV's, but we are losing our



Fig. 37. M-1 Handitester

personal ability to understand and appreciate the relative simplicity of the past, as well as understand the present. Much has been gained by advances, but something also has been lost. Radio collectors and radio historians help correct this for the benefit of our future.

REFERENCE NOTES

1. Heathkit 1955 Catalog, "Mr. Heathkit" pp. 2 and 3.
2. Chuck Penson WA7ZZE, *Heathkit - A Guide to Amateur Radio Products*, 2nd Edition, CQ Communications, Inc., Hicksville, New York, 2003. This is an excellent resource on early Heath people, the history of Heath, and the evolution of specific products. Also included is detailed information on all Heathkit amateur radio products with photographs and descriptions of each.
3. Ron Grossman, Pulling the Plug, *Radio Age*, Volume 17, No. 9, p. 2-4, September 1992. Source: *The Chicago Tribune*, May 3, 1992, *Radio Age* editors Donald and Norma Patterson, Augusta, Georgia. The *Radio Age* article is taken from the *Tribune* article. A very nice article on Heathkit history and events surrounding the discontinuation of kits in 1992.
4. *Heathkit Nostalgia*, Terry Perdue, 1992 (privately printed, but widely available). A brief history of the Heath Company, including photographs of the Heath Parasol airplane and interviews of many early persons responsible for Heathkit. A must-read for anyone with interests in Heathkit collecting and the persons who made it all possible.
5. John Dilks, "Old Radio - Heathkit", *QST*, p. 86 and 87, August 2004. Provides a nice history of Edward Heath and Howard Anthony, and the early history of the Heath Company and Heathkits.
6. *General Radio Company Catalog D*, 257 pages, Cambridge,

Massachusetts, June 1956. Type 650-A Impedance Bridge, 650-A Battery Type \$270.00, p. 28.

ACKNOWLEDGEMENTS

I want to thank Jay Whipple, Jr. for access to his significant Heathkit collection, Patricia B. McGroarty for assembling the manuscript and tables, Susan E. Golebiowski for her photographic expertise and assistance, the encouragement of William Ross, and my wife Frances for her endless patience and support as I spent years on the kitchen table going over reference sources. Without the help of these five individuals, this article would still be a work in progress.

PHOTO CREDITS

Photos by Susan E. Golebiowski.

ABOUT THE AUTHOR

Erich E. Brueschke BSEE, M.D., FAAFP, KC9ACE currently holds an Extra Class amateur radio license. He held the call WØBPS from 1948 when he was in high school. He has a B.S. in Electrical Engineering from the South Dakota School of Mines and Technology. He worked for the Hughes Research and Development Laboratories in Culver City, California for five years, specializing in magnetics and in the effects of high vacuum on outer space components. His last Hughes effort was on the Surveyor spacecraft in 1961-1962, which landed on the moon in 1966. He left Hughes to go to medical school at Temple University School of Medicine in Philadelphia. After training, he was a captain in the U.S. Air Force at the Aerospace Medical Research Laboratories at Wright Patterson Air Force Base in Dayton, Ohio. He subsequently practiced family medicine in California and then

joined the IIT Research Institute in Chicago, where he worked on artificial internal organs, including powering the artificial heart, for seven years. He then joined Rush Medical College in Chicago where he was Chairman of Family Medicine and subsequently became Dean of Rush Medical College for six years. He retired as Dean in 2000. He is currently the Distinguished Professor of Medicine at Rush Medical College of Rush University in Chicago. He has two patents issued and has published numerous papers in engineering, medical, and the scientific literature, and is a member of numerous professional societies. His major collecting and restoration interests are early scientific and medical instruments, early battery radios and Heathkits. He has collected radios and scientific devices for over 27 years. He has been a member of the AWA for 20 years.



Erich Brueschke

Heathkit

Table I: Heathkit Database 1947-1956 - By Date First Advertised or Probable Introduction

Source: *Radio News / Radio and Television News 1947-1956*

Model	Description	Date First Advertised ("Probable" estimates date introduced since not advertised)	Date Last Advertised (through Dec-56)	Price
O-1	5" Oscilloscope (First Pictured Sep-47), First Heathkit Instrument	Jul-47	Jan-48	39.50
V-1 Type 1 of 3	VTVM (Painted Handle, Toggle Switch, 5 Ranges)	Dec-47	Jun-48	24.50
301	Pocket Tester Kit	1948 <i>Heath Surplus Flyer</i> Only		3.95
A-1	25 Watt Amplifier 4-Tube	Jan-48	Mar-48	14.95
G-1 Type 1 of 3	Signal Generator, Painted Handle	Jan-48	Jun-48	19.50
None	Transmitter Kit	Jan-48	Mar-48	19.50
None	12" PM Speaker for A-1 or A-2	Feb-48	Dec-49	6.95
O-2	5" Oscilloscope, Toggle Switches (Painted Handle)	Feb-48	Jun-48	39.50
None	Midget Amateur Transmitter	Mar-48	Aug-48	3.95
None	Midget Amateur Transmitter Key	Mar-48	Aug-48	1.00
None	Midget Amateur Transmitter Battery	Mar-48	Aug-48	3.25
A-2	24 Watt Amplifier	Apr-48	Dec-49	14.50
G-2 Type 1 of 3	Sine and Square Wave Audio Generator, Toggle Switch, Terminals on Right - [:] Painted Handle	Apr-48	Jun-48	34.50
HS-30	Headphones for K-1 or K-2	May-48	Dec-49	1.00
K-1	All-Wave, Left Speaker, 3-Tube, AC Price increased to \$8.75 Jun-48	May-48	Jun-48	5.95

K-1	All-Wave, Left Speaker, Battery 2-Tube Price increased to \$8.75 Jun-48	May-48	Jun-48	5.95
K-1 or K-2 Accessory	2.5" PM Speaker for K-1 or K-2	May-48	Dec-49	1.95
K-1 or K-2 Accessory	Battery Set for K-1 or K-2	May-48	Jul-48	3.25
IP-1*	Interphone 2-Way Call System	May-48	Mar-49	14.50
T-1	Signal Tracer	May-48	Mar-49	19.50
IB-1	Impedance Bridge 10-0 Main Dial, C-R-L	Jun-48 Probable		69.50
IB-1A	Impedance Bridge 0-10 Main Dial, L-R-C	Jun-48	Mar-51	69.50
G-1 Type 2 of 3	Signal Generator, Aluminum Handle	Jul-48	Dec-48	19.50
G-2 Type 2 of 3	Sine and Square Wave Audio Generator, Toggle Switch, Terminals on Lower Right - [..]	Jul-48	Mar-49	34.50
K-2	All-Wave, Right Speaker, AC	Jul-48	Dec-49	8.75
K-2	All-Wave, Right Speaker, Battery	Jul-48	Jul-48	8.75
O-3 Type 1 of 2	5" Oscilloscope, Toggle Switches (Aluminum Handle)	Jul-48	Mar-49	39.50
V-1 Type 2 of 3	VTVM (Aluminum Handle, Toggle Switch)	Jul-48	Mar-49	24.50
C-1 Type 1 of 2	Condenser Checker, Toggle Switch	Sep-48	Mar-49	19.50
S-1 Type 1 of 2	Electronic Switch (Toggle Switch)	Sep-48	Nov-48	34.50
G-3	Sweep Generator	Oct-48	Mar-49	24.50
None	Photo Timer	Oct-48 <i>Flyer Only</i>		8.75
K-2 Accessory	Long Wave Coil for K-2, 200- 500 Kc	Nov-48 <i>Flyer</i>	Jan-49 <i>Flyer</i>	0.90
K-2 Accessory	Short Wave Coil for K-2, 6000-21000 Kc	Nov-48 <i>Flyer</i>	Jan-49 <i>Flyer</i>	0.90
None	Mahogany Speaker Cabinet A-2	Dec-48	Dec-49	8.75

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S-1 Type 2 of 2	Electronic Switch (Slide Switch)	Dec-48	Mar-50	34.50
G-1 Type 3 of 3	Signal Generator, No Logo	Jan-49	Aug-49	19.50
K-2 Accessory	Mahogany Cabinet	Jan-49	Dec-49	2.95
216	Miniature Headphones	Feb-49 <i>Flyer Only</i>		1.00
309	RF Crystal Probe for VTVM Price reduced to \$5.50 Jan-51	Mar-49	Apr-53	6.50
310	10,000 HV Test Probe for VTVM	Mar-49	Aug-50	4.50
312	Tool Kit	Mar-49	Dec-49	5.95
BE-1	Battery Eliminator	Mar-49	Aug-50	22.50
FM-1	FM Tuner	Mar-49	Dec-49	14.75
None	FM Tuner Cabinet	Mar-49	Dec-49	3.75
O-3 Type 2 of 2	5" Oscilloscope (Slide Switch)	Mar-49 Probable		39.50
TC-1 Type 1 of 5	Tube Checker (Double Rollers), May Be Prototype	Mar-49	May-49	29.50
TC-1 Type 2 of 5	15 pos Filament Switch with "off," Has Logo	Mar-49 Probable		29.50
TC-1 Type 3 of 5	14 pos Filament Switch with "off," Has Logo	Mar-49 Probable		29.50
V-1 Type 3 of 3	VTVM (Slide Switch for "on-off")	Mar-49 Probable		24.50
V-3	VTVM Battery	Mar-49	May-49	34.50
C-1 Type 2 of 2	Condenser Checker, Slide Switch	Apr-49	Dec-49	19.50
G-2 Type 3 of 3	Sine and Square Wave Audio Generator, Slide Switch, Terminals on Lower Right	Apr-49	Mar-51	34.50
G-4	HF-AM Signal Generator	Apr-49 Probable		Unknown
O-4	5" Oscilloscope (Slide Switch)	Apr-49	Aug-49	39.50
T-2	Signal Tracer	Apr-49	Aug-52	19.50
TS-1	TV Alignment Generator	Apr-49	Dec-49	39.50
V-2	VTVM First with 6 Ranges	Apr-49	Nov-49	24.50
TC-1 Type 4 of 5	No Filament Switch "off," Has Logo	Jun-49	Oct-52	29.50
315	Converts O-3 or O-4 to O-5	Sep-49	Aug-50	12.50
316	Conversion Kit G-1 to G-5 (Vernier)	Sep-49	Aug-50	4.50

G-5	Signal Generator (Vernier Version of G-1)	Sep-49	Aug-50	19.50
M-1	Handitester Price increased to \$14.50 Sep-53	Sep-49	After Dec-56	13.50
O-5	5" Oscilloscope (Push-Pull Circuit)	Sep-49	Aug-50	39.50
None	8" Hi Fi Speaker for BR-1	Sep-49 <i>Flyer Only</i>		8.50
V-2A	VTVM (Larger Meter) No Logo	Nov-49 Probable		24.50
320	5" PM Speaker for AR-1 or BR-1	Dec-49	Mar-51	2.75
335	Metal Cabinet for AR-1 or BR-1	Dec-49	Jul-51	4.50
AR-1	3-Band Receiver	Dec-49	Aug-53	23.50
BR-1	Broadcast Receiver	Dec-49	Aug-53	23.50
V-4	VTVM (Larger Meter)	Dec-49	Aug-50	24.50
A-3	Amplifier	Jan-50 Probable		Unknown
A-4	6 Watt Amplifier	Jan-50	Mar-52	12.50
C-2	Condenser Checker	Jan-50	Aug-52	19.50
None	12" Speaker for A-4 (Becomes 304)	Jan-50	Aug-50	6.95
TS-1A	TV Alignment Generator	Jan-50	Aug-50	39.50
None	7" Raytheon TV Receiver Kit	Jul-50	Jul-50	34.50
None	7" Raytheon TV Receiver Kit - 18 Tubes	Jul-50	Jul-50	20.00
None	7" Raytheon TV Receiver Kit - Mahogany Cabinet	Jul-50	Jul-50	20.00
None	7" Raytheon TC Receiver Kit, 18 Tubes and Mahogany Cabinet	Jul-50	Jul-50	69.50
BE-1A	Battery Eliminator	Aug-50 Probable		22.50
304	12" Speaker for A-4	Sep-50	Mar-52	6.95
326	12" 20 Watt Speaker	Sep-50	Mar-51	7.50
336	Or 3366 - 30,000 VDC Probe VTVM	Sep-50	After Dec-56	5.50
345	Birch Cabinet for AR-1 or BR-1	Sep-50	Jul-51	4.95
350	FM Tuner Cabinet - Birch	Sep-50	Jul-51	4.95
A-5	20 Watt Amplifier	Sep-50	Mar-52	21.50
A-5A	20 Watt Amplifier with Preamplifier	Sep-50	May-51	23.50

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BE-2	Battery Eliminator	Sep-50	Oct-51	22.50
FM-2	FM Tuner	Sep-50	May-55	24.50
O-6	5" Oscilloscope	Sep-50	Aug-51	39.50
PS-1 Type 1 of 2	Variable Power Supply (Screw Terminals)	Sep-50	Aug-52	29.50
RD-1	Resistance Decade 1/2%	Sep-50	Aug-52	19.50
S-2	Electronic Switch Price increased to \$23.50 Jan-54	Sep-50	Aug-55	19.50
SG-6	Signal Generator	Sep-50	Aug-52	19.50
TS-2	TV Alignment Generator	Sep-50	Aug-53	39.50
V-4A	VTVM (Change in AC Balance Ckt)	Sep-50	Aug-51	23.50
AG-7	Sine and Square Wave Audio Generator	Apr-51	Aug-52	34.50
IB-1B	Impedance Bridge 0-10 Main Dial, C-R-L	Apr-51	Aug-53	69.50
A-6	20 Watt Amplifier	May-51	May-51	33.50
A-6A	20 Watt Amplifier with Preamplifier	May-51	Mar-52	35.50
AF-1	Audio Frequency Meter	Sep-51	Mar-54	34.50
AV-1	A.C. VTVM	Sep-51	Aug-52	29.50
IM-1	Intermodulation Analyzer	Sep-51	Mar-54	39.50
O-7	5" Oscilloscope	Sep-51	Aug-52	43.50
SQ-1	Square Wave Generator	Sep-51	Mar-54	29.50
V-5	VTVM	Sep-51	Apr-52	24.50
BE-3	Battery Eliminator	Nov-51	Aug-53	24.50
A-7	6 Watt Amplifier	Apr-52	Aug-53	14.50
A-7A	A-7 with Preamplifier	Apr-52	Aug-53	16.50
A-8	20 Watt Amplifier	Apr-52	Aug-53	33.50
A-8A	A-8 with Preamplifier	Apr-52	Aug-53	35.50
WA-A1	Williamson Amp with Preamp	Apr-52	Oct-52	69.50
WA-B1	Williamson Amp Only	Apr-52	Oct-52	49.75
WA-P1	Preamplifier Only	Apr-52	Mar-54	19.75
V-5A	VTVM (Change in Tube Compliment)	May-52	Aug-52	24.50
PS-1 Type 2 of 2	Variable Power Supply (Binding Posts)	Aug-52 Probable		29.50

337	Scope Demodulator Probe	Sep-52	Apr-53	4.50
338	Peak to Peak Probe for VTVM	Sep-52	Apr-53	6.50
339	Intensifier Kit for O-8	Sep-52	Apr-53	7.50
355	TV Picture Tube Adapter for TC-1 or TC-2	Sep-52	After Dec-56	4.50
AG-8	Audio Generator	Sep-52	After Dec-56	29.50
AO-1	Sine and Square Wave Audio Oscillator	Sep-52	After Dec-56	24.50
AV-2	A.C. VTVM	Sep-52	Aug-56	29.50
BT-1	Battery Tester	Sep-52	Mar-54	7.50
C-3	Condenser Checker	Sep-52	Dec-56	19.50
DC-1	DC-1 Decade Condenser 1%	Sep-52	After Dec-56	16.50
DR-1	Decade Resistor 1%	Sep-52	After Dec-56	19.50
GD-1	Grid Dip Meter with 6 Coils	Sep-52	Apr-53	19.50
O-8	5" Oscilloscope	Sep-52	Aug-53	43.50
PS-2	Regulated Power Supply	Sep-52	May-54	29.50
QM-1	"Q" Meter	Sep-52	After Dec-56	39.50
RS-1	Resistance Substitution Box	Sep-52	After Dec-56	5.50
SG-7	Signal Generator	Sep-52	Aug-53	19.50
T-3	Signal Tracer	Sep-52	After Dec-56	4.40
V-6	VTVM, 7 Ranges	Sep-52	Aug-54	24.50
VC-1	Voltage Calibrator	Sep-52	Apr-53	9.50
VT-1 Type 1 of 2	Vibrator Tester (No Socket Labels)	Sep-52	After Dec-56	14.50
VT-1 Type 2 of 2	Vibrator Tester (With Socket Labels)	Oct-52 Probable		14.50
W-1	Amplifier	Oct-52 Probable		Unknown
365	Portable Birch Cabinet for TC-1	Nov-52	Aug-53	7.50
TC-1 Type 5 of 5	Larger Meter, No Logo	Nov-52	Aug-53	29.50
TC-1P	TC-1 in Birch Portable Cabinet	Nov-52	Aug-53	34.50
W-2	Williamson Amp with WA-P1 Pre Amp	Nov-52	Aug-54	69.50
W-2M	Williamson Amp Only	Nov-52	Aug-54	49.75
W-3	Williamson Amp with WA-P1 Pre Amp Price increased to \$71.50 Sep-56	Nov-52	After Dec-56	69.50
W-3M	Williamson Amp Only	Nov-52	After Dec-56	49.75

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None	Planning Service Shop	Mar-53	Apr-53	0.00
None	Establishing Ind. Elec. Lab	Mar-53	Apr-53	0.00
None	Basic Service Shop (7 Kits)	Mar-53	Apr-53	149.50
None	Typical Laboratory (11 Kits)	Mar-53	Apr-53	263.50
AW-1	Audio Wattmeter	Apr-53	After Dec-56	29.50
IB-2	Impedance Bridge	Apr-53	After Dec-56	59.50
AT-1	Amateur Transmitter CW	May-53	After Dec-56	29.50
BG-1	Bar Generator	May-53	May-55	14.50
GD-1A	Grid Dip Meter with 5 Coils (see 341)	May-53	Aug-53	19.50
VC-2	Voltage Calibrator	May-53	Aug-55	11.50
A-7C	A-7B with Preamplifier	Jul-53	Aug-55	17.50
A-9	Amplifier	Jul-53 Probable		Unknown
A-9A	20 Watt Amplifier	Jul-53	Mar-54	35.50
RP-1	Dual Record Player	Jul-53	Dec-53	59.50
A-7B	6 Watt Amplifier	Aug-53	Aug-55	15.50
341	Low Frequency Coils for GD-1A	Sep-53	May-55	3.00
342	Low Capacity Probe (Scope)	Sep-53	After Dec-56	3.50
362	Heathkit Binding Posts (20 ea)	Sep-53	Mar-54	4.00
309B	RF Probe for VTVM	Sep-53	Mar-54	3.50
337B	Scope Demodulator Probe	Sep-53	Mar-54	3.50
338B	Peak to Peak Probe for VTVM	Sep-53	Mar-54	5.50
91-8	Portable Tube Checker Cabinet (see 365)	Sep-53	Aug-55	7.50
91-9	Cabinet for BR-2 with Panel	Sep-53	Jul-56	4.50
AC-1	Antenna Coupler	Sep-53	After Dec-56	14.50
AM-1	Antenna Impedance Meter	Sep-53	After Dec-56	14.50
AR-2	Communications Receiver	Sep-53	Aug-55	25.50
BE-4	Battery Eliminator	Sep-53	After Dec-56	31.50
BR-2	Broadcast Band Receiver Price increased to \$19.25 Sep-56	Sep-53	After Dec-56	17.50
GD-1B	Grid Dip Meter with 5 Coils (see also 341A)	Sep-53	After Dec-56	19.50
IT-1	Variable Voltage Isolation Transformer	Sep-53	After Dec-56	16.50
LG-1	Laboratory Generator	Sep-53	After Dec-56	39.50

MM-1	Multimeter	Sep-53	After Dec-56	26.50
None	Tech. App. Bulletin	Sep-53	Mar-54	2.00
None	Service Shop Notes	Sep-53	Mar-54	0.00
O-9	5" Oscilloscope	Sep-53	Aug-54	59.50
SG-8	Signal Generator	Sep-53	After Dec-56	19.50
TC-2	Tube Checker (Lighted Chart)	Sep-53	After Dec-56	29.50
TC-2P	Portable TC-2	Sep-53	After Dec-56	34.50
TS-3	TV Alignment Generator	Sep-53	Mar-55	44.50
91-10	Cabinet with Aluminum Panel for AR-2	Oct-53	Dec-55	4.50
RP-2	Dual Record Player	Jan-54	Mar-54	69.50
A-9B	20 Watt Amplifier	Apr-54	After Dec-56	35.50
W-4	Amplifier with Preamp	Apr-54	Aug-55	59.50
W-4M	Amplifier Only	Apr-54	Aug-55	39.75
WA-P2	Preamplifier Price increased to \$21.75 Sep-56	Apr-54	After Dec-56	19.75
PS-3	Regulated Power Supply	Jun-54	After Dec-56	35.50
OL-1	5" Oscilloscope	Aug-54	Aug-56	29.50
OM-1	5" Oscilloscope	Aug-54	Aug-56	39.50
309C	RF Probe	Sep-54	After Dec-56	3.50
337C	Scope Demodulator Probe	Sep-54	After Dec-56	3.50
338C	Peak to Peak Probe for VTVM	Sep-54	After Dec-56	5.50
341A	Low Frequency Coils for GD-1B	Sep-54	May-55	3.00
CS-1	Condenser Substitution Box	Sep-54	After Dec-56	5.50
O-10	5" Oscilloscope	Sep-54	Aug-56	69.50
V-7	VTVM, 7 Ranges	Sep-54	Aug-55	24.50
VF-1	VFO (Matches AT-1)	Sep-54	After Dec-56	19.50
TS-4	TV Alignment Generator	Apr-55	Aug-56	49.50
AA-1	Audio Analyzer	Jun-55	After Dec-56	59.50
CM-1	Direct Reading Capacity Meter	Jun-55	Dec-56	29.50
DX-100	Phone and CW Transmitter	Jun-55	After Dec-56	189.50
HD-1	Harmonic Distortion Meter	Jun-55	After Dec-56	49.50
W-5M	Amplifier Only	Jun-55	After Dec-56	59.75
A-7D	7 Watt Amplifier Price increased to \$18.65 Sep-56	Sep-55	After Dec-56	16.95
AG-9	Audio Generator	Sep-55	After Dec-56	34.50

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AR-3	All Band Receiver Price Increased to \$30.75 Sep-56	Sep-55	After Dec-56	27.95
CC-1	CRT Tube Checker	Sep-55	Dec-56	22.50
FM-3	FM Tuner with Cabinet - Gold	Sep-55	Aug-56	24.50
LP-1	Linearity Pattern Generator	Sep-55	Jun-56	22.50
QF-1	"Q" Multiplier	Sep-55	After Dec-56	9.95
V-7A	VTVM (Last of V Series), 7 Ranges	Sep-55	After Dec-56	24.50
W-4A	Amplifier with WA-P2 Preamp Price increased to \$61.50 Sep-56	Sep-55	After Dec-56	59.50
W-4AM	Amplifier	Sep-55	After Dec-56	39.75
91-15A	AR-3 Cabinet Price increased to \$4.95 Sep-56	Jan-56	After Dec-56	4.50
W-5	W-5M Amp plus WA-P2 Preamp Price increased to \$81.50 Sep-56	Jun-56	After Dec-56	79.50
BC-1	AM Tuner Price increased to \$26.95 Sep-56	Jul-56	After Dec-56	24.50
CR-1 Type 1 of 2	Crystal Receiver with Headphones Price increased to \$8.75 Sep-56	Jul-56	Dec-56	7.95
DX-35	Phone and CW Transmitter	Jul-56	After Dec-56	56.95
ET-1	Enlarger Timer	Jul-56	After Dec-56	11.50
LP-2	Linearity Pattern Generator	Jul-56	After Dec-56	22.50
None	FM-3, A-7E, and SS-1	Jul-56	After Dec-56	82.95
RC-1	Radiation Counter	Jul-56	After Dec-56	79.95
S-3	Electronic Switch	Jul-56	After Dec-56	21.95
SS-1	Speaker System	Jul-56	After Dec-56	39.95
SS-1B	Range Extending Speaker	Jul-56	After Dec-56	99.95
91-9A	Proxylin Cabinet for BR2	Sep-56	After Dec-56	4.95
A-7E	A-7D with Preamplifier Price increased to \$20.35 Sep-56	Sep-56	After Dec-56	18.50
AV-3	A.C. VTVM	Sep-56	After Dec-56	29.50
FM-3A	FM Tuner	Sep-56	After Dec-56	26.95
O-11	5" Oscilloscope	Sep-56	After Dec-56	69.50

OM-2	5" Oscilloscope	Sep-56	After Dec-56	42.50
TS-4A	TV Alignment Generator	Sep-56	After Dec-56	49.50
VC-3	Voltage Calibrator	Sep-56	After Dec-56	12.50
XO-1	Electronic Cross-Over	Sep-56	After Dec-56	18.95
CR-1 Type 2 of 2	Crystal Receiver, Daystrom on Panel, with Headphones Price increased to \$8.75 Sep-56	After Dec-56		7.95
* IP-1 model also shown in November 1948 <i>Popular Mechanics</i> , p 293				

AWA Review

Swan Island, its radio history including the CIA and the revenge of United Fruit

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ABSTRACT

Swan Island in the Caribbean, once a pirate lair, can tell many related radio stories. It shows a century of communications technology in the real world of commerce, geo-politics, war and weather. United Fruit Company put Swan Island to work as its long wave spark wireless relay station for its sea-borne commerce in bananas and sugar. Swan Island thereafter provided an ideal site for researching the Caribbean hurricanes. In the Cold War, Latin American insurgencies surrounded Swan Island. In opposing them, the American Central Intelligence Agency, with remarkable connections to United Fruit, once again put Swan Island to work -- for "black ops" and propaganda. The CIA enjoyed Swan Island's advantages for nearly four decades of covert action. Now, Swan Island once again provides a sunny, peaceful lair for its big Iguanas, with an occasional visit from amateur radio operators.

Swan Island, between Honduras and Cuba (Figure 1), amounts to just over three-square miles of very little: coral, palms and big iguanas. But from the standpoint of radio, it does have "location, location, location" and some very interesting radio tales to tell. United Fruit Company used it first as a wireless telegraphy relay station *circa* 1911. In 1960 through 1968, the American Central Intelligence Agency (CIA) used it as a propaganda and clandestine station against Cuba on short wave and in the broadcast band. As *Radio Swan*, it broadcast anti-Castro programming and operational messages for the ill-fated Bay of Pigs invasion in 1961. Then as *Radio Americas*, it broadcast propaganda to Cuba, all of which was preceded by a little known CIA pirate radio operation on Swan Island in the previous decade.

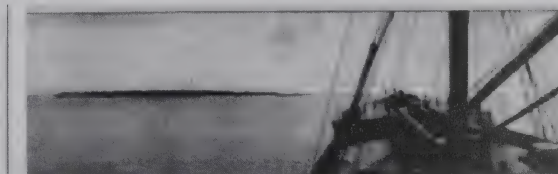


Fig. 1. Swan Island on the Horizon, c. 1922, occupied by United Fruit since 1909, named after Pirate Captain Charles Swan of the *Cygnnet* in the 17th Century. (Radio Broadcast, Vol. 1, No. 1, May, 1922 [1])

Real pirates based themselves on Swan Island long before radio pirates. Captain Charles Swan, sailing his smuggling ship (and later outright pirate) *Cygnnet*, visited in the late 17th Century while working for pirate Henry Morgan. Swan Island is about as far from other places as an island in the Caribbean Sea can be. The somewhat grandiosely called Grand Island is the one usable island in a group of three. It is barely big enough for the small airstrip put in for the CIA about 1960. Sea Captain Alonzo Adams originally claimed it for the United States as a guano island, bird guano being a valued fertilizer in the 19th century. The Boston family

of Sumner Smith owned the island, having acquired it from Captain Adams. Its central location made it ideal for a relay radio station and for broadcasting to nearby countries, as well as for the earlier Caribbean pirates. See Figures 2 & 3, for a map of its ocean location and a map of its minimal geography.

Bananas are central to Swan Island's radio history. In the early 20th century, bananas had become the fruit of choice, largely as a result of promotion by the Boston Fruit Company, which evolved into the United Fruit Company and then Chiquita Brands. Only bananas (and oranges) were available year round. A "bunch" consists of many "hands" of individual bananas; each banana is a finger. "*Banan*" means finger in Arabic; early globalization at work. In 1922, United Fruit asserted that it had imported 284,000,000 bunches of bananas in the last ten years, and that it did a \$10,000,000 a year Latin American mercantile business. Adjusted for inflation that is \$130,000,000. [1] Today, the per capita American consumption is about 25 pounds

each. Today, Latin America exports about 17 million metric tons of bananas a year.

United Fruit imported boat-loads of bananas and considerable sugar from Central American countries known, in O. Henry's phrase, as "banana republics." As a vertically integrated enterprise, United Fruit planted the producing trees and sugar cane. Then it managed the plantations for export, and then it provided the transportation to American markets. It also opened schools and medical facilities and employed many tens of thousands of people. It operated railroads and provided regional communications and transport. It owned a million and a half acres of land but cultivated only 365,000 acres, as of 1922, and employed 67,000 people in Guatemala, Costa Rica, Cuba, Honduras, Jamaica, Panama and the Canary Islands, and in the United States. [1]

To appreciate the role of Swan Island in intrigue as well as commerce, the United Fruit Company should be understood to have had three subsidiaries at various times:



Fig. 2. The Caribbean Sea, Swan Island (arrow) in its midst, South West of the Caymans and Cuba, North east of Guatemala, enjoying only 'Location, Location, Location' (Google Maps)

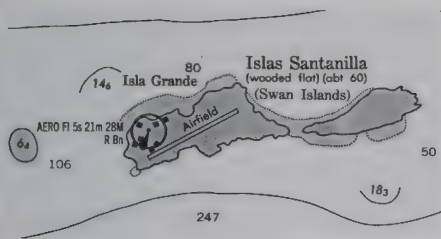


Fig. 3. Swan Island, as shown on a current navigational map showing the 1961 airstrip, beacon and structures.

1) the company known as Wireless Specialty Apparatus Company, Inc.;

2) the country known as Guatemala; and

3) “the company” known as the CIA, the United States Central Intelligence Agency.

The CIA first landed on Swan Island in 1954, in a little known episode in the ether wars. It set up a “black-ops” radio broadcasting network including a powerful Swan Island transmitter, to effect the CIA-sponsored overthrow of the elected government in Guatemala – and it worked, although largely executed by propaganda radio sta-



Fig. 4. A wireless telegraphy shore station of the first decade of the 20th century; a spark gap on an induction coil to the right, Leyden jar condensers to the left, clock center, inker for recording received signals and in front of it, a coherer detector, and to the left of the coherer, the tuner for reception. This is a reconstruction of the Marconi station at Lizard Point, Cornwall, UK; curator David Barlow. (Photo Bart Lee, 2005).

tions in nearby countries closer to Guatemala City. The utility and location of Swan Island in the 1954 operation likely made Swan Island the prime candidate for the site of the 1961 operation that became *Radio Swan*.

SWAN ISLAND AS UNITED FRUIT COMPANY'S CENTRAL WIRELESS RELAY STATION

Untoward delay in the distribution of tropical bananas caused great loss. Wireless telegraphy made itself indispensable at sea, *circa* 1909, (see Figures 4 & 5, Marconi state-of-the-art shore and ship stations). United Fruit saw its advantages for coordinating its extensive “Great White Fleet” of banana boats. It could maximize efficiency and provide weather warnings. The range of long-wave spark systems was, however, limited. This necessitated relay stations. United Fruit created a network of wireless stations extending from the interiors of the countries hosting its plantations such as Guatemala, to the gulf coast of the United States,



Fig. 5. A Marconi ship station (Empress of Britain, callsign MPB), tuner to the left, as reconstructed at the British Museum. (Photo Bart Lee, 2002)

especially Florida and New Orleans and up to Boston. United Fruit sited one station on Swan Island. It had initially leased some of the island from Sumner Smith's Swan Island Company of Boston to grow coconuts. Figure 6.

United Fruit sought reliable wireless apparatus in the dawn of the radio age. Good gear was hard to find, and often had to be hand-crafted to specifications. Wireless Specialty Apparatus Co., Inc., (WSA) was a then "high-tech" company with an excellent reputation and it was conveniently located in Boston. One of its principals was Greenleaf Whittier Pickard, an outstanding Harvard educated engineer who had worked for American Wireless Telephone and Telegraph Company briefly, *circa* 1902, then American Telephone and Telegraph Company (AT&T) until 1906, and who then consulted briefly for Lee de Forest (although he seems to have left that episode

off his biography). He then joined the Boston company in 1907. Pickard invented and developed numerous mineral crystal detectors for reception of wireless signals, and contributed the technology of the point contact junction, known colloquially as the "cat's whisker." Wireless Specialty Apparatus detectors and wireless sets, especially its IP-501 receivers, were known in their day for their reliability, and are known to this day for their quality and collectability.

United Fruit bought WSA in 1912 so it would have a source of reliable and increasingly powerful radio equipment. See Figure 7. United Fruit enjoyed the advantages of this equipment at sea and shoreside. Figure 8. United Fruit also took advantage of the skills and diligence of its corps of competent, innovative and clever wireless operators. [2]

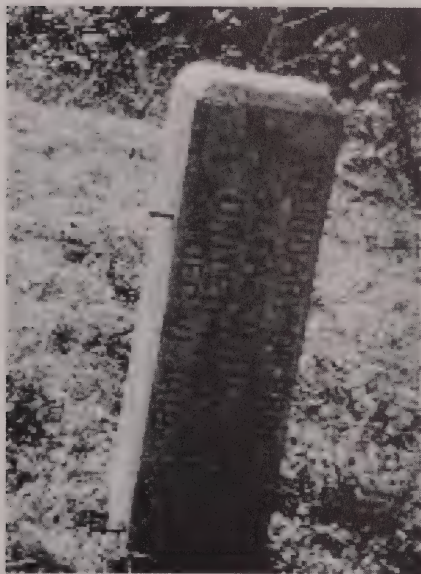


Fig. 6. Swan Island Boundary Marker 1912: "Boundary of Property Leased to the United Fruit Co Dec 10, 1912" (From Tom Kneitel, Dec., 1985 [8])

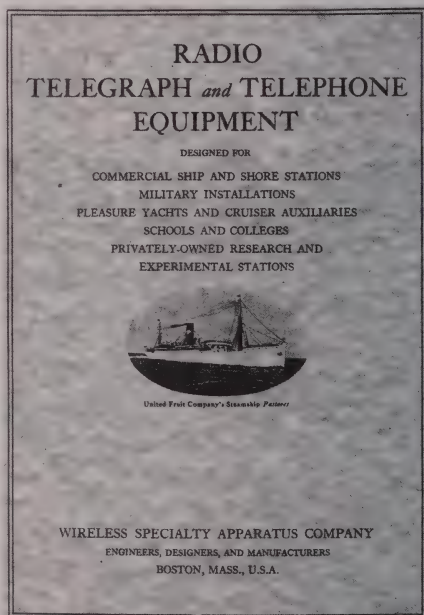


Fig. 7. Cover of a catalog, circa 1922, of Wireless Specialty Apparatus Company, a Subsidiary of United Fruit Company; UFCO Steamship Pastores is on the cover. (Author's collection).

United Fruit soon developed one of the earliest successful radio networks that carried public traffic as well as its own. See Figure 9 for an image of a United Fruit Wireless frank. As of 1913 the network became the Tropical Radio and Telegraph Company, also headquartered in Boston.

United Fruit so dominated Latin American communications with state-of-the-art technology and an integrated radio system that the founders of the Radio Corporation of America monopoly

(RCA, beginning in 1919) including American Marconi, Westinghouse, General Electric and AT&T, in 1921 included United Fruit Company and its subsidiary WSA in an exchange of traffic facilities.

Swan Island had beckoned a decade earlier, *circa* 1909, as an ideally centrally situated relay station site. Swan Island could communicate with the nearby countries of Latin America to the West and with Cuba to the North East, the Canal Zone to the South and New Orleans to the North. It could

also relay traffic and especially hurricane and storm warnings to and from United Fruit ships at sea and to United Fruit operations West of it. By 1911 Wireless Specialty Apparatus spark transmitters sparked away, and very tall antenna masts rose above Grand Swan. United Fruit also had the foresight to employ Edison Cell battery backup power both in its vessels and at its stations. Some of the worst hurricanes on record with winds estimated at 200 knots by reliable observers have battered United Fruit's commercial region centered on Swan Island. The batteries proved



The United Fruit Co.'s Steamship *Turrialba* at Santa Marta, Colombia



WIRELESS SPECIALTY APPARATUS installation on the United Fruit Co.'s Steamship *Turrialba*

[10]

Fig. 8. A United Fruit Company banana boat and its wireless room, circa 1921 (from Radio Broadcast, May, 1922 [1])



Fig. 9. A pre-paid 1912 'stamp' for a UFCO Wireless Service message; in 1913 this was renamed Tropical Radio Company, which with Wireless Specialty Apparatus became part of RCA in 1919 when it absorbed United Fruit Company's radio operations. (Author's collection).

their worth but ultimately the tall masts always fell down. More than once, all that was left on Swan Island were a few stone or concrete buildings, everything else having been flattened or swept out to sea.

The scale of United Fruit's radio undertaking may be judged from the number of stations and the high power WSA equipment that was largely identical in each station. According to a definitive May, 1922 article about United Fruit Company and its Wireless Network in the first issue of *Radio Broadcast* magazine (probably written by United Fruit's already effective public relations department) [1], the land stations were:

Radio Stations UFCO 1922; note that callsigns for Central American stations start with "U" for United plus a second letter, and two of three US station's callsigns end in "U":

Radio Stations: Call Letters:
 New Orleans, Louisiana WNU
 Burrwood, Louisiana WBU
 Fort Morgan, Alabama WIO
 Swan Island, Caribbean Sea
 US [United-Swan]
 Tela, Honduras UC
 Puerto Castilla, Honduras
 UA
 Tegucigalpa, Honduras UG
 Port Limon, Costa Rica UX
 Almirante, Panama UB
 Santa Marta, Colombia UJ

In the days before federal regulation and in the unregulated Caribbean, the first letter of a self-assigned callsign often represented the company, e.g., D for De Forest Wireless, P for Pacific Wireless, and here, U for United Fruit, and a second letter often related to its site. Caribbean stations *circa* 1912 were:

KW at Key West operated by De Forest with a two kilowatt spark rig and an audion detector receiver,

M at Havana, Cuba operated by Marconi with a ten-inch induction coil transmitter and a Fleming Valve receiver,

TD at Trinidad, Cuba with a Telefunken ½ KW spark and crystal detector receiver,

US at Swan Island operated for United Fruit's Tropical Wireless Telegraph Company with a one KW spark transmitter and WSA's Perikon crystal detector but also an electrolytic detector.

Two of the ships of the day were the tug *SS Rescue*, callsign RSQ, with a Massie Wireless Telegraph Company ten-inch induction coil and crystal detectors, and the banana transport *SS Olinda*, callsign OA, with a United Wireless Telegraph Company half KW spark, and crystal detectors. [3] These vessels may have had radio operators aboard from the companies

that supplied the equipment such as Massie, just as Marconi operators went to sea on various companies' vessels.

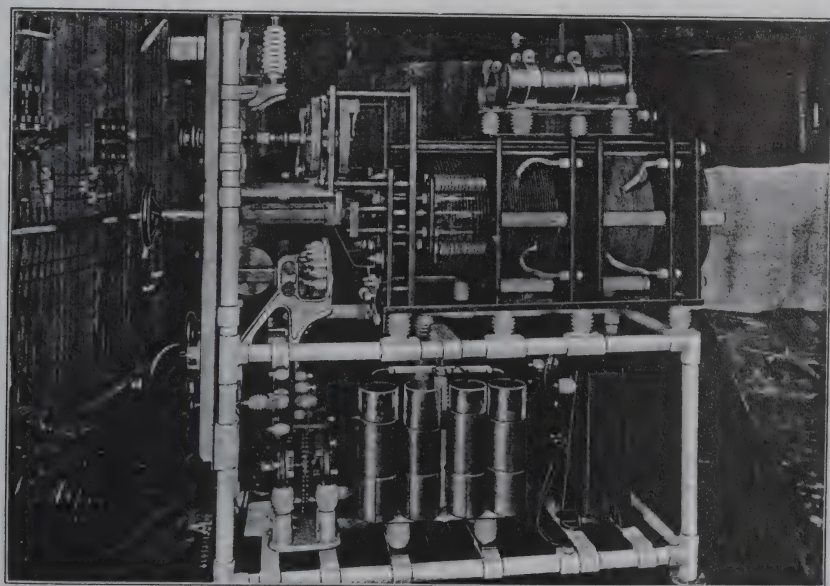
Wireless Specialty Apparatus Company proudly displayed its equipment including that installed on Swan Island in its catalogs. Figures 10 & 11. The *Radio Broadcast* article also shows the equipment at work ashore and at sea. Similarly, Thomas Edison published an illustrated promotional "Letter" [4] about the use of his batteries by United Fruit's wireless stations, on ships and on land. See Figures 12 & 13.

Operations at the inland stations, and island stations such as Swan Island, initiated, relayed and received a great deal of traffic. Some of it was distress traffic with lives at stake at sea. During hurricane season, the lives of the station operators themselves were at stake. One of the old operators,

E. Jay Quinby, (Commander, USN, Ret.) wrote an exciting, if hyperbolic fictionalized reminiscence *Marooned in Paradise* [3] about service by wireless man "Jack Fogerty" on Swan Island *circa* 1912, where the iguanas were said to reach five feet in length:

"... DAMN the tropics and DAMN Fred Muller back there in Boston for talking him into accepting this assignment at Swan Island, which he described as a "veritable tropical Paradise in the Caribbean Sea." Muller hadn't mentioned the inevitable malaria, the poisonous vipers, the loathesome [sic] creatures that crawled by night and the clouds of winged pests that swarmed by day and raised itching welts to torture a man's soul hour by hour, day by day, night by night."

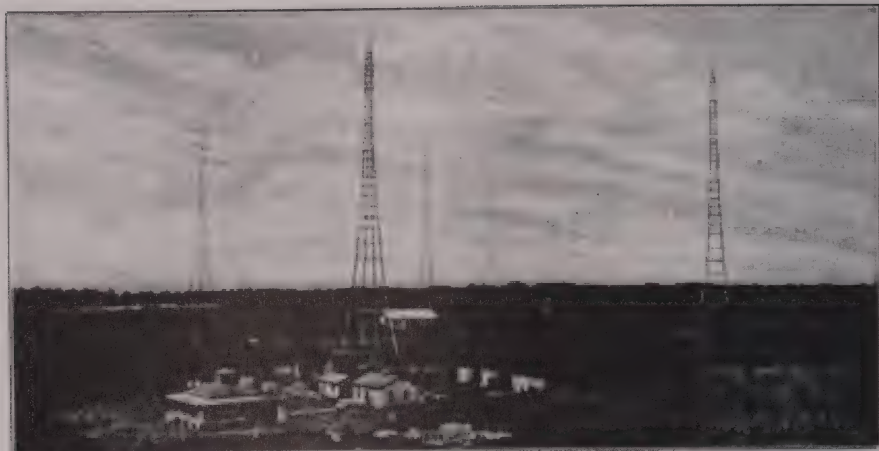
Then, the CQD of the storm-distressed *SS Olinda* rouses malaria-fevered operator Fogerty (sine JF)



5 K.W. Transmitter designed and built by the WIRELESS SPECIALTY APPARATUS COMPANY and installed in the United Fruit Company's station at Swan Island, Caribbean Sea

[70]

Fig. 10. From the WSA catalog, a 5 KW quenched gap spark transmitter working on Swan Island circa 1920.



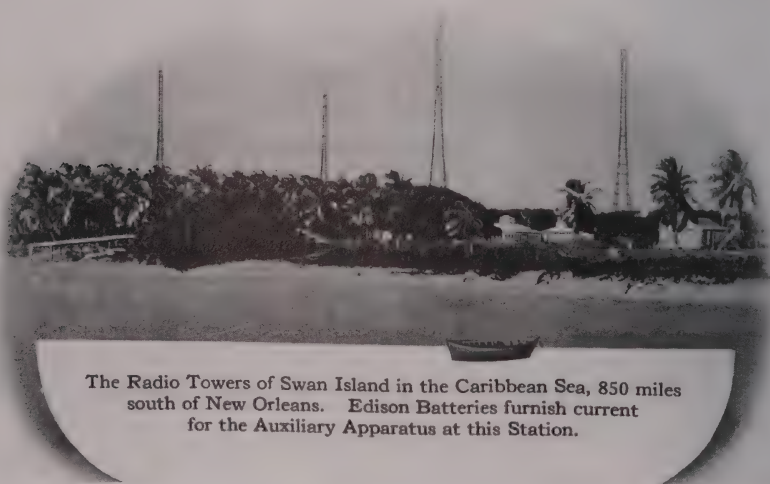
Swan Island Station of the United Fruit Co., equipped with a K.W. Wireless Specialty transmitter and receiver.

Fig. 11. The WSA catalog's picture of the Swan Island station and four towers, circa 1920.

to action. But then the stormwind takes down an antenna guywire and Jack and a native helper have to reconnect it in the near hurricane gales. Then the relay of the distress call meets weather challenges before getting to Cuba but finally reaches the rescue tug *SS Rescue* out of Key West. *SS Rescue* saves the *Olinda* from the rocks just in time, with everybody talking

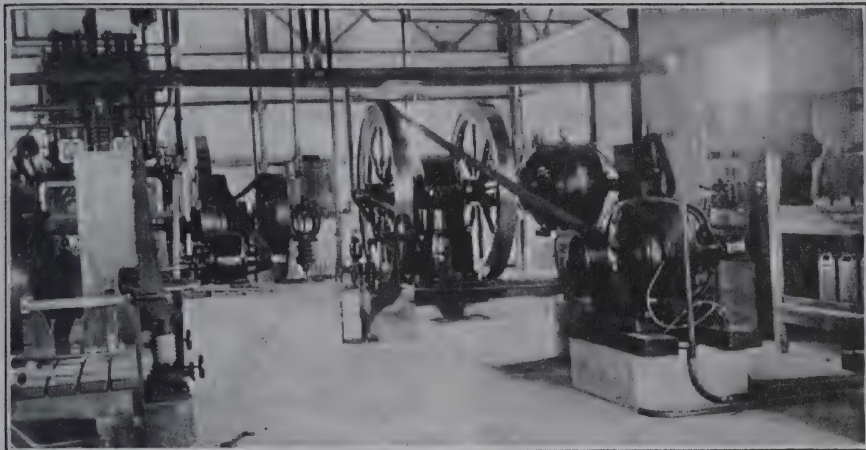
to everybody by wireless throughout the rescue. In the process JF manages to talk the operator of the *Olinda*, and old acquaintance, into replacing him on Swan Island, telling him that the Swan Island girls are beautiful: "... ask Fred Muller, he will tell you about them." It's quite a story; it rings true.

Later operators at Swan Island may have, at least occasionally, en-



The Radio Towers of Swan Island in the Caribbean Sea, 850 miles south of New Orleans. Edison Batteries furnish current for the Auxiliary Apparatus at this Station.

Fig. 12. The Edison Company's 1915 picture of the UFCO Swan Island station, looking from the North. (Edison promotional "Letter" [4])



View No. 1. Edison Batteries Operating Auxiliary Apparatus at Swan Island Station

Fig. 13. UFCO's Swan Island station's motor-generators working on emergency battery power; from the Edison Company 1915 promotional "Letter" about such battery operation. (Edison promotional "Letter" [4])

joyed the place more ... or at least United Fruit seems to have wanted it to seem that way. See Figure 14.

SWAN ISLAND AS WEATHER CENTRAL

The United Fruit Company wireless operation on Swan Island became an official weather

Below. View of the Radio Station at Swan Island, once the haunt of buccaneers in the days of the Spanish Main



Above. In spite of its loneliness and perils, the Swan Island radio men are not always depressed



Fig. 14. Happy Swan Island wireless operators enjoying island duty at the radio station on Swan Island, or so United Fruit would have one believe, above right: "In spite of loneliness and perils, the Swan Island radio men are not always depressed." Left caption reads; "View of the Radio Station, once the haunt of Buccaneers in the days of the Spanish Main." (Radio Broadcast, May, 1922 [1])

station in 1914. With the coming of vacuum tube CW technology after 1920 as well as short wave point-to-point radio circuits, relay stations had little role to play in the Caribbean. Swan Island receded to the background as a hurricane-observing weather station between 1928 and 1932. The Weather Bureau placed observers on Swan Island during the hurricane season in 1938, and more permanently in 1940. [5]

Weather observations became increasingly precise, and the hope of accurately predicting hurricane paths and strengths provided ample justification for research. The weather stations operated on Swan Island employed radio links of their own. But many of the weathermen were also amateur radio operators. The FCC at first issued KD4 callsigns, then KS4 callsigns; Swan Island became a very rare DX (distant) entity for amateur radio operators collecting countries and jurisdictions contacted over the air. A series of QSL verification cards collected by Thomas Roscoe,

K8CX, (used here by permission) tells the story of the Swan Island amateur radio stations and that of the weather station. [6] One of the more interesting cards, a club station [8], plays on the pirate theme. See Figure 15.

In 1946, the FAA had installed a non-directional navigation beacon radio station for guidance of Caribbean air traffic, callsign SWA. [5] In 1953 KS4AU's Swan Island QSL card (Figure 16) shows affiliation with PAA, Pan American Airlines, "on the route of the Flying Clippers." Pan Am started out as a Caribbean air carrier in 1927 and became the American national airline flying world-wide. Pan Am may have maintained a communications installation or, inasmuch as it was a primary user, it may have maintained the air navigational beacon on Swan Island.

The 1963 QSL card of W3ZQ/KS4 (Figure 17) says "site of the U.S. Weather Bureau Hurricane Upper Air Sounding Station (supported by FAA communications)." The FAA radio station used the

callsign WSG and communicated with Miami by radio-teletype. [8]

Although weather can be exciting enough in that part of the world, clandestine radio is what really put Swan Island on the historical map.



Fig. 15. Swan Island Amateur Radio Club (according to Tom Kneitel [8]), operator James Takaki, KH6BCB/KS4 in 1968, remembering Captain Swan. Takaki had a Hawaiian call, and had also operated as F7BY, probably also on government service. These QSL card images were collected by Thomas Roscoe, K8CX, <http://hamgallery.com>; this one KS4CC via K8CX from OE1HGW.

(NOT SO) COLD WAR RADIO ON SWAN IS- LAND

Radio Swan's role as a CIA anti-Castro station in 1960 before, during and after the disastrous Bay of Pigs invasion, has long been of interest to historians of geo-politics and historians of radio. [7] Radio

historian and journalist Tom Kneitel, K2AES, wrote extensively about Swan Island radio [8] as early as 1968, the year he visited its later *Radio Americas* incarnation.

But *Radio Swan* had its origin in the astonishingly successful 1954 CIA clandestine radio stations beaming propaganda and more into Guatemala. The station on Swan Island was set up by CIA officers E. Howard Hunt, later of Watergate fame, [10] and propaganda specialist David Atlee

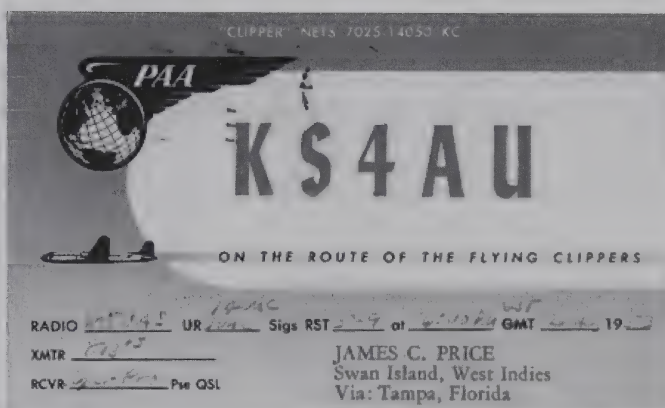


Fig. 16. "On the Route of the Flying Clippers" "PAA" (Pan American Airways) says KS4AU's 1953 QSL card. Via K8CX from W8UAS.

Phillips. [11] The CIA called its campaign PBSUCCESS and the propaganda broadcasters called themselves, in Spanish, The Voice of Liberation, *La Voz de Liberacion*.

In Guatemala at the time, United Fruit "... functioned as a state within a state, owning Guatemala's telephone and telegraph facilities, administering its only Atlantic harbor, and monopolizing its banana export" as well as all the railroad track (887 miles), and it controlled 40,000 employees. [12] United

Fruit grew a lot of bananas in Guatemala then. It owned a lot of land that it kept in reserve, paid little in taxes, and opposed what many considered appropriate reforms. And therein hangs a tale.

The Boston roots of United Fruit ran deep. It operated from Boston and ran its Revere Sugar

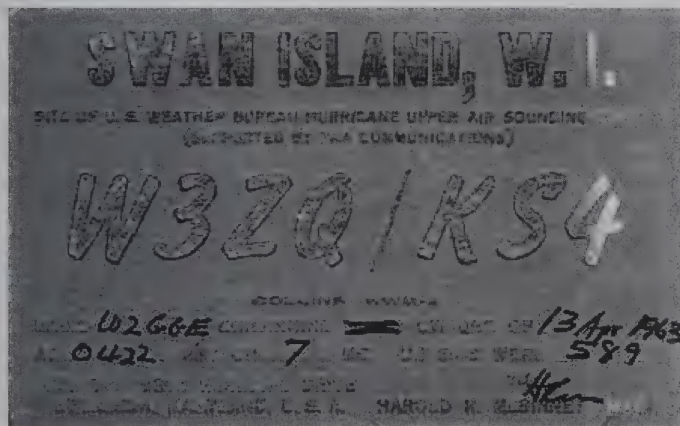


Fig. 17. W3ZQ/KS4 QSL card from 1963: "Site of the U.S. Weather Bureau Hurricane Upper Air Sounding Station (Supported by FAA Communications)"; Via K8CX From W2GGE.

Refinery at Boston. [1] Boston is also that place where "[in] the land of the bean and the cod, the Lodges talk only to Cabots, and Cabots talk only to God." In fact at the time of the CIA's Guatemalan operation, the American Ambassador to the United Nations was Henry Cabot Lodge (who presumably could talk to himself if need be). He was later Richard Nixon's 1960 running-mate [13] and a stockholder in United Fruit. [14] United Fruit connected to the U.S. Government at the highest level:

"The American Secretary of State John Foster Dulles was an avowed opponent of Communism whose law firm of Sullivan and Cromwell had represented United Fruit. His brother Allen Dulles was the director of the CIA, and was a board member of United Fruit. The brother of the Assistant Secretary of State for InterAmerican Affairs John Moors Cabot had once been president of United Fruit. Ed Whitman who was United Fruit's principal lobbyist was married to President Eisenhower's personal secretary [...]" [15]

Both Dulles brothers owned stock in United Fruit. [16]

One summary explains the CIA's Guatemalan operation, code-named PBSUCCESS, thus:

"The 1954 Guatemalan coup d'état was a covert operation organized by the United States Central Intelligence Agency to overthrow Jacobo Arbenz Guzmán, the democratically-elected President of Guatemala. Arbenz's government put forth a number of new policies, such as seizing and expropriating unused, unfarmed land that private corporations set aside long ago and giving the land to peasants, that the U.S. intelligence community deemed Communist in nature and, suspecting Soviet influence, fueled a feared of Gua-

temala becoming what Allen Dulles described as a 'Soviet beachhead in the western hemisphere.' Dulles' concern reverberated within the CIA and the Eisenhower administration, in the context of the anti-Communist fears of the McCarthyist era. Arbenz instigated sweeping land reform acts that antagonized the U.S.-based multinational company United Fruit Company, which had large stakes in the old order of Guatemala, and lobbied various levels of U.S. to take action against Arbenz. [...] The operation, which lasted from late 1953 to 1954, planned to arm and train an ad-hoc 'Liberation Army' of about 400 fighters under the command of a then-exiled Guatemalan army officer, Colonel Carlos Castillo Armas, and to use them in conjunction with a complex and largely experimental diplomatic, economic, and propaganda campaign. The operation effectively ended the experimental period of representative democracy in Guatemala known as the 'Ten Years of Spring,' which ended with Arbenz's official resignation." [16]

Radio propaganda and radio "black ops" brought success to the CIA's operation PBSUCCESS. Radio historian Don Moore has called the CIA's Guatemalan radio operation, *La Voz de Liberacion*, "The Clandestine Granddaddy of Central America." [17]

The CIA landed E. Howard Hunt and David Atlee Phillips (Figure 18) and their equipment on Swan Island in 1953. According to Hunt this was done to implement the propaganda campaign by means of radio. [18] Hunt also reported that shortly after landing, a boatload of Guatemalan "students" tried to come ashore to stop them, but Hunt persuaded them otherwise. He did not say exactly how they were persuaded,

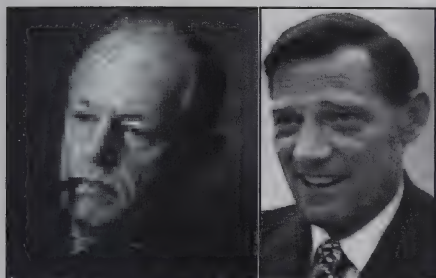


Fig. 18. According to E. Howard Hunt, above left, the CIA landed him and David Atlee Phillips, right, on Swan Island in 1953 to set up a high power propaganda shortwave radio station to be used against Guatemala. He reported that they had to repulse "Guatemalan students" who objected. [18]

but Phillips provided propaganda expertise throughout the exercise while Hunt was the presumably fully-armed initial operations man. There also must have been at least some of a Navy Construction Battalion (SeaBees) on site given the size of the radio station and its towers and the transmitter's ten kilowatts output on shortwave in the 49 meter band.

The CIA officers who have written about Guatemala have always been subject to agency censorship. So, suppression of Swan Island's exact role in the overthrow of Guatemala's government is possible, perhaps by reason of the diplomatically sensitive and long pending Honduran claim to the island. Hunt in his 2007 book says that the main CIA "channel" was "stationed across the Honduran border..." [10] According to Moore, the broadcasts came primarily, if not entirely, from Nicaragua: "CIA technicians set up a complete radio base camp on a remote Nicaraguan farm. Additional transmitters were located in Honduras, the Dominican Republic, and even in the US embassy in Guatemala City." Moore is relying heavily on Phillips' account, but Phillips never

reveals the site or sites of origin of the broadcasts. Moore goes on to say: "Although it was never used, a reserve transmitter was set up on Swan Island (which seven years later would be the site of the CIA's famous anti-Castro clandestine, *Radio Swan*)." [17]

E. Howard Hunt, who had landed on Swan Island with Phillips, wrote: "From neighboring Honduras, our powerful transmitter overrode the Guatemalan national radio, broadcasting messages to confuse and divide the population from its military overlords." [10] "[O]ur powerful transmitter" may suggest the high-powered Swan Island installation with multiple directional antennas mounted on high towers. Phillips says that the transmitter was "Too distant from Guatemala City for conventional medium wave signals, [so] it [had] to be on the short-wave band." [11] Moreover, according to Phillips, short-wave radio was popular in Guatemala for a variety of reasons. (AM broadcast stations typically enjoy a daytime range of 50 to 150 miles although at night this range extends considerably farther. [19] Swan Island is about 200 miles East of Guatemala.) Most of Nicaragua is more than 200 miles from Guatemala, and Honduras borders Guatemala, about 100 miles from Guatemala City to the West. Looking at the relative distances, Swan Island cannot be ruled out as an operational site. [11]

The broadcasts sowed confusion and despair among the Arbenz government and the Guatemalan Army. It was classic psychological warfare. According to Hunt, it was all recorded in Miami and then transmitted in proximity to Guatemala. [10]

The broadcasts featured "radio-games," the kind of *funkspiel* so effective for the NAZIs against the

British Special Operations Executive (SOE) in Holland. *La Voz de Liberacion* told The Big Lie, little lies, shams, disinformation, and claimed fake battles won, fake desertions and the like. The *funkspiel* convinced Col. Arbenz that the invading Guatemalans (who were ragtag U.S. sponsored insurgents, and see Appendix for some of their radio equipment) would defeat his regime. His duly-elected government capitulated and many of its members fled. The *coup d'etat*, enabled by black ops radio, succeeded so well that it surprised even its originators in the CIA. According to Phillips, a British diplomat concluded that: "The soldiers had nothing to do with it. The war was won by that radio station." [11]

United Fruit avoided expropriation, "U.S. interests," co-incident with those of United Fruit, were served, and Guatemala suffered from decades of bloody unrest, as did much of Central America. Arbenz and his circle may well have been communists, and he did import a shipload consisting of a thousand tons of East Block arms. Later CIA analysis, however, suggests that the Soviet Union played little if any role in these events. Nonetheless, "black ops" radio had proved its worth. [20] United Fruit got what it wanted. The new ruler, Col. Armas, ruled by "kow-towing to United Fruit" according to Phillips. [11]

From a present day perspective, it can look as though United Fruit manipulated the CIA into doing its dirty work for it in Guatemala, albeit most of it was done bloodlessly by radio. A *realpolitik* point of view, however, may make more sense. The deeply interconnected post World War Two American institutions, such as big business companies using new techniques of public relations, big labor, and the

government agencies of the day, thrived as a successful sovereign in a challenging world. America had competed throughout the world with other sovereignties such as the NAZIs, and in the new Cold War, faced the Soviet Union. In the case of Guatemala, the CIA was merely the high-technology tactical operator that emphasized propaganda radio more than regiments of infantry. The CIA did not work for United Fruit; the CIA worked for "America, Inc."

Irrespective of the success of PBSUCCESS, in this period, Swan Island remained as vulnerable to hurricanes as earlier. In particular, a Navy man wrote this report about Hurricane *Janet* in 1955 (see Figure 19 for her track):

"... on September 15 ... [a]t 1100 hours, from our closed retreat, we heard the giant twin radio towers crash to the ground after being knocked from their foundations by the 100-knot wind ..." [21]

A P2V Neptune hurricane research aircraft with eleven aboard flew into *Janet* east of Swan Island. It radioed in its position, and then was lost and "never heard from again" after its report of "Velocity estimated 200 knots. Beginning penetration." [21] The following recollection by a crew member in the Navy's 1955 search and rescue operation for that P2V shows what a hurricane can do:

"As we approached Swan Island we could not contact them by radio until we got close, as the only power and radio they had was an emergency transceiver that was operated by hand cranking a small generator in the unit that was called a Gibson Girl. Because the sea state was too great to land, and there was no way to get near the island with beaching gear, as we did not have wheels, and even if we did have wheels there was



Fig. 19. The CIA overthrew the Guatemalan government, Swan Island's radio stood down, and then Hurricane Janet came by in 1955 with 200 knot winds, blowing down all antenna towers.



Fig. 20. Che Guevara and Fidel Castro. In the Cuban Revolution - 1959 - declared communists took over Cuba. Cuba expropriated United Fruit's and other U.S. interests on the island, and imprisoned and executed many thousands of Cubans. Some 9,389 Cubans have been listed by name as murdered by Che and Fidel and "the Revolution." ("The Revolution is not a dinner party" said Mao Tse Tung.)

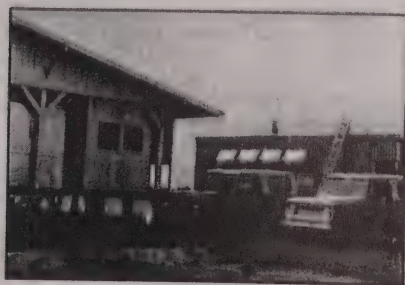


no runway on the island at the time. What we did see when we got there was the islands covered with downed coconut trees that were laid out like match sticks and clearly lined-up indicating how the wind blew them down. There were also five (5) huge radio transmitters, flat on the ground and parallel to each other, and also indicating the direction of how the hurricane winds blew over the island." [22]

RADIO SWAN TAKES ON CASTRO, AND FAILS

Within five years after Guatemala's *coup* ousted the communist sympathizers of Guatemala, Cuba played host to the related communist insurgency of Fidel Castro. Che Guevara, who had been in Guatemala and who had seen what black ops radio propaganda could do, played a major role in Cuba — Hunt later regretted letting him escape Guatemala. Figure 20. This time, the Soviets enthusiastically embraced the Cuban Revolution, Monroe Doctrine or not. Needless to say, the Cuban Revolution also expropriated properties of United Fruit. But the 1961 American attempt to oust Castro failed as spectacularly as the Guatemalan effort had succeeded, and the Cuban Missile Crisis followed 18 months later.

La Voz de Liberacion provided a model for a propaganda and black ops campaign against Cuba, and Swan Island played a central role. There has been a great deal



RS transmitters were portable jobs mounted in vans parked under a roof. The small announcers studio building is at the right, though most of the programming was on tape and flown in from Miami. (Photo by Tom Kneitel)

Fig. 21. CIA officer David Phillips got another radio station up on Swan Island in 30 days, with help from the Navy. (Illustration from Tom Kneitel, *Popular Communications*, Dec. 1985, p. 20 [8]); see also *Clandestine Confidential* [7].

of discussion in the radio hobby, as well as among historians, about *Radio Swan*, whose short wave and medium wave broadcasts could be heard throughout the United States. Once again the CIA, courtesy of the U.S. Navy, landed CIA officers including David Atlee Phillips. The CIA, courtesy of the SeaBees, installed transmitter for the medium wave broadcast band at 1160 kHz at 50,000 watts power (50 KW), and another for short wave at 6 MHz at 3,000 to 10,000 watts (10 KW). Once again large antenna towers arose. The CIA took the big transmitter out of a technically ineffective propaganda operation in West Germany. Philips is likely to have suggested Swan Island as a result of his 1954 operations there.

Philco Corporation had a division that could put a turnkey radio station wherever the government wanted it and they did so. [7, 11] Operated by 15 Philco engineers of its "Tech Rep Flying Squad" [23] in wheeled trailers, (Figure 21) *Radio Swan* took to the air.

A CIA internal memorandum tells the story:

"Brief History of Radio Swan.

"1. On 17 March 1960, President Eisenhower approved a covert action to bring about the replacement of the Castro regime. Within the propaganda framework of that program, an important objective was to create and utilize a high-powered medium and short wave radio station. CIA was asked to provide such a station, outside the continental limits of the United States, and have it ready for operation within sixty (60) days.

"2. Swan Island, in the Caribbean, was chosen as an appropriate site. The United States Navy furnished CIA with splendid support: within sixty days, equipment had been brought from Europe, a

landing strip was cleared on the island, and the station was able to go on air on 17 May of the same year, precisely on schedule.

“3. Originally it was planned that Radio Swan would be a clandestine station utilizing a “classified missile and space project” as cover. Just prior to inauguration, however, it was decided the station should be a commercial one. This was at the request of the Navy, which reasonably argued that should their participation in construction of a black facility be known, explanations would be difficult.

“4. Using a ‘commercial’ station for the tactical and strategic tasks envisaged for Radio Swan is not, of course, the most desirable way to support a covert operation. The only practical method of operation is to “sell space.” Thus, program time on Radio Swan was sold to various Cuban groups. These included organizations of workers, students, women, two publications in exile, two radio stations in exile, and several political groups. There were also programs created and controlled by CIA. Programs (on tape) were produced in New York, Miami, and later, on Swan Island.” [24; (page 1 of 5)]

Boston, the land of the bean, cod and United Fruit, provided the CIA with the initial programming and broadcasting for its Cuban propaganda operation from short wave station WRUL. [25] The principal of WRUL in Boston was Walter S. Lemmon. WRUL had played a role in World War Two American shortwave broadcasting, and Lemmon was well connected in Washington. In April, 1960 WRUL began broadcasting anti-Castro programming. It then linked up with Radio Swan, providing programming for that station. A company of Lemmon’s also sold

air-time on Radio Swan. [26]

One summary provides interesting detail, with Boston and United Fruit once again involved:

“In 1960, Radio Swan commenced unlicensed transmissions in May as a commercial radio station ... operating with a power of 50,000 watts on AM 1160 [kHz] and on shortwave with a power of 7,500 watts on 6000 kHz. The importance of this island was in its location and proximity to the island of Cuba, because on March 17, 1960, U.S. President Dwight D. Eisenhower had approved covert action to topple the regime of Fidel Castro in Cuba. As early as October 30, 1960, the Castro government sent reconnaissance flights over Swan Island and the Caribbean Coast of Guatemala ... Swan Island was claimed by the governments of both the United States and Honduras, although the island was in the de facto hands of personnel acting on behalf of the U.S. Central Intelligence Agency (CIA). The person who claimed ownership in the press was Sumner Smith of Boston. He was both the president of Abington Textile and Manufacturing Works and a stockholder in Gibraltar Steamship Company of New York City.

“While the Federal Communications Commission (FCC) claimed that it had no jurisdiction over the station, the address of Radio Swan was in care of the Gibraltar Steamship Company in New York, which was a CIA proprietary company. The station later claimed to be owned by Vanguard Service Corporation. Its president was Thomas D. Cabot, a former president of the United Fruit Company and a US State Department executive in the Truman Administration. The station also used a post office box in Miami, Florida.

“The AM transmitter in use by

Radio Swan had been used by Radio Free Europe and it was taken to Swan Island by U.S. Navy personnel. At first all broadcasts of this pseudo-commercial radio station were in the Spanish language and it was announced on air as *Radio Swan, la Voz Internacional del Caribe*, with its initial commercial programming coming on tape recordings from anti-Castro political groups in exile.

"Cuba responded to the broadcasts by setting up a jamming station to block the transmissions of Radio Swan and initiated *La Voz de INRA*, or *The Voice of INRA* which represented the National Institute of Agrarian Reform with an anti-American message. This action was followed on January 3, 1961, by a break in diplomatic relations between both countries that had been initiated by the USA. Following this action, Cuba commenced broadcasting to the USA and to the world, with a new international

service called Radio Havana Cuba.

"In March 1961 Radio Swan announced that it would no longer sell its airtime for political programming and the station changed to an all-news format while infusing its broadcasts with coded messages. The station described itself as *assisting those who are fighting Castro within Cuba* and it began transmitting on fourteen frequencies. The CIA issued a press release claiming its anti-Castro broadcasts were now being beamed by seven radio stations as well as Radio Swan. During the Bay of Pigs Invasion of Cuba, which took place between April 15 - April 19, 1961, it became obvious to all concerned that the purpose of the station was to assist in the landings. But following the abortive invasion, Radio Swan suddenly changed format again. While its tone remained anti-Castro its programming did not promote an uprising against the Cuban government. Then, the sta-

tion changed its format and name. Radio Swan became Radio Americas and it remained on the air until May 1968 when the station closed down and its AM transmitter was transported to South Vietnam to assist in the wars of South-East Asia." [27]

Radio Americas freely disclosed on its QSL card (Figure 22) that it operated at 50 KW AM on



Fig. 22. A 1966 QSL card from Radio Americas. Radio Swan first broadcast to Cuba along the same lines as the radio propaganda against Guatemala. Before and during the 1961 CIA Bay of Pigs invasion, Radio Swan provided both operational and disinformation transmissions. President Kennedy denied air support to the insurgents and Castro's forces repulsed them. Radio Swan continued as a propaganda station, as Radio Americas ("purposelessly" said CIA officer David Phillips [11]). Courtesy Hank Tester and Harry Helms via Thomas Roscoe, K8CX.

1160 kHz from two vertical towers, presumably phased to beam to Cuba. For shortwave, with a nominal 7.5 KW RCA transmitter, it employed a full wave dipole antenna, again with directionality to Cuba.

Phillips says the operator was a CIA proprietary company called "Gulf [*sic*; Gibraltar] Steamship Company," which he says was "... the only corporation available in the CIA's secret portfolio...." and which he knew owned no boats. Sumner Smith, who asserted that he owned Swan Island, was a stockholder of Gibraltar Steamship Company according to several

sources [see, *e.g.*, 27]. Phillips goes on to say: "A team of civilian contract technicians and a single CIA security officer manned Swan Island." That transmitter took its programming primarily from CIA studios in Miami under the aegis of the "steamship company." The CIA security officer on Swan Island, with only a side-arm, once had to play host to invading Honduran "students" asserting sovereignty. Happily they were more interested in partying than conquest. [11] After the failure of the Bay of Pigs operation (and the subsequent Missile Crisis), *Radio Swan* as *Radio Americas* nonetheless continued on the air for seven years. According to CIA officer Phillips: "Radio Swan continued to broadcast purposelessly." [11] Cuban exiles continued agitation (see Figure 23); nothing more happened except lots of mutual spying, short wave numbers stations sending coded messages (or pretending to), and exile harassment of Cuba (Figure 24) and Cuban harassment of exiles.

To this day, *Radio Havana* may be heard nightly in the 49 meter band, on 6000 kHz, the old frequency of *Radio Swan*, in sort of a short wave radio time warp. Fidel and Raul Castro remain dictators devoted to communism, while the Soviet Union, as Karl Marx himself predicted for the State after the Dictatorship of the Proletariat, just faded away.

MORE WEATHER, MORE INTRIGUE; SWAN ISLAND'S COLD WAR CODA

Swan Island remains. The United States turned it over to Honduras in 1972, after a lawsuit with Sumner Smith's family, reserving the right to operate (at least) the weather station, run by NOAA, the National Oceanographic and

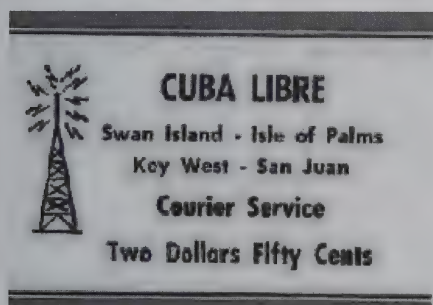


Fig. 23. Cuban exiles continued (and continue) anti-Castro agitation. This courier label dates from the 1960s in Miami. It may reflect a shipping circuit among CIA radio-related installations.

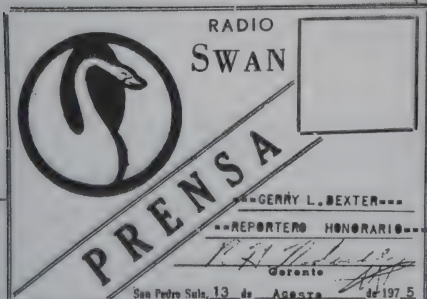


Fig. 24. An honorary press card for a noted SWL DXer and writer, Gerry Dexter. This Radio Swan in Honduras claimed to be a successor operated by Cuban exiles, but went off the air when communists took its antenna down in 1976 with explosives. From [7] Gerry Dexter, *CLANDESTINE CONFIDENTIAL* at p. 29.

Atmospheric Administration. Amateur radio operators on Swan Island go on the air as Honduran stations. Figure 25. They now use the HQ8 identifier. Figures 26 & 27

Swan Island's central position has enabled it to assist in rescues. These include the one reported for 1912 and the *SS Olinda*. In 1975 NOAA awarded its Gold Medal for lifesaving to two of its weathermen who responded to an SOS:

"1975 Gold Medal -- Spencer Bennett and Randolph Moore, Islas del Cisne Meteorological Station, Honduras -- Messrs. Bennett and Moore are recognized for heroic action during a storm, December 10, 1974, on Islas del Cisne (Swan Island), a tiny weather observing outpost in the Caribbean. During this storm they rescued 19 shipwrecked fishermen at a great risk to their own lives. The Honduran fishing vessel *Lucky Girl* encountered heavy seas about 20 miles northwest of Islas del Cisne. The hull ruptured and the ship began to sink rapidly. The Captain sent an SOS and then ordered all hands to abandon ship. The SOS was picked up by the Swan Island Meteorological Station, and personnel there responded immediately. The Swan Islanders launched two small motorboats into the rough seas to seek survivors of the *Lucky Girl*. Demonstrating superb seamanship in heavy seas in outboard motorboats, they successfully searched out and towed to Swan Island eight dugout canoes, containing nineteen men. Because of their courage, not a single life was lost." [28]

Radio Swan, however, had a short-lived ghost or two. In 1975, another anti -communist *Radio Swan* took to the air, [Figure 23] on 6186 kHz and medium wave. It claimed a relation to Swan Island's *Radio Swan*, although it broadcast from Honduras. Its principal had been an anti -Castro insurgent at the Bay of Pigs. Explosives took out

the station's antennas in 1976, and it went dark. [29]

In the 1980s the CIA, despite Honduran sovereignty, used Swan Island for a base for supplying *Contras* dedicated to the overthrow of the elected Sandinista government in Nicaragua. Private supporters of the *Contras* also used Swan Island, presumably with the blessing of the CIA. Headlines of the day reported events such as: PLANE SUPPLYING CONTRAS CRASHES; 11 BELIEVED KILLED IN NICARAGUA; PLANE STRUCK BY MISSILES. [30] The Reagan administration's CIA attempt to continue to fund *Contras* through dealings with Iran caused the great Iran-Contra scandal in 1986.

The *Contras* also used clandestine radio stations in Honduras. As a Nicaraguan military intelligence official reported in June of 1989:

"... add the military role played by the *contra* radio stations. 15th of September Radio, Radio Liberation and the Radio System of the Resistance continue functioning in Honduras. What is even more important is the system of command through the radios, the military circuit between Tegucigalpa and the Strategic Command and between the latter and the units along the border. That whole network has remained intact..." [31]

Swan Island remained in the center of Central American intrigue even in the late 1980s:

"[A] small station ... was established on Swan Island in support of a variety of operations which were being conducted as part of our support for the CIA's efforts in Nicaragua. This facility was centered on an airstrip, which was used as a base of operations for pilots who were dropping supplies to the rebels, which the CIA was supporting. The communications setup for this facility was something that we called a flyaway

package. Basically it consisted of a HF [high frequency] transmitter/receiver[,] a PC-based communications terminal and a KG-84 encryption device.” [32]

A similar but satellite-enabled “flyaway package” saw service in Haiti in 1994 and in Bosnia. [33]

After a while, with the demise of the Soviet Union, most of Central America sorted itself out, communists to the left. In Venezuela, Hugo Chavez is everything Col. Arbenz ever wanted to be, but he has oil instead of bananas. The Castro

brothers still rule the Cuban Socialist Paradise, although they have discontinued the daily “free lunch.” Poor people remain abysmally poor, and very unhappy. One can still listen to *Radio Havana Cuba* on 6 MHz, with *Radio Marti* from Florida in counterpoint. But the glory days of Swan Island have given way to satellite communication and internet propaganda. Maybe now the iguanas of Swan Island, as well as visiting amateur radio operators, will be able to flourish in peace. “Have a banana.”



Fig. 25. HR6SWA, Swan Island, Honduras, 1975. Note the suffix SWA is the same as the FAA Beacon callsign. On Sept. 1, 1972, the United States yielded Swan Island to Honduras, keeping the right to operate on the island. Via K8CX from K8CX.

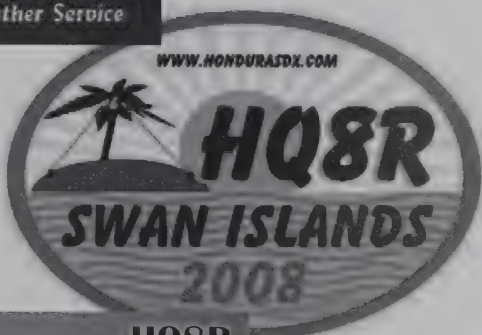


Fig. 26. This is the DXpedition HQR logo for 2008 IOTA (Islands on the Air) operation from Swan Island. www.hondurasdx.com.



Fig. 27. The most recent (2008) QSL card from Swan Island, HQR; Peace at Last.

REFERENCE NOTES

1. *United Fruit Company and its Wireless Network*, in RADIO BROADCAST magazine ([first issue] Vol. 1, No. 1) May 1922, at p. 377. This article reads as if written by United Fruit, one of the first companies to see the advantages of “public relations”: land stations and callsigns of UFCO, p. 398.
2. UFCO wireless operators circa 1911 had effected a crude but very sensitive regeneration circuit invented by Paul E. Wallace in New York using a de Forest Audion in the “Wallace Valve Detector” configuration that de Forest would himself soon adopt as his RJ-4. The young Edwin Howard Armstrong heard the Wallace regenerative circuit in operation in the summer of 1911 and the next year invented regeneration as we know it. The Wallace device sailed on UFCO ships *SS Santa Marta*, *SS Almirante* and *SS Carillo*, installed by wireless pioneer Robert H. Marriott, and also served at the UFCO wireless station in Colon in the Panama Canal Zone. Gerald F. Tyne, *The RJ-4 Mystery*, Antique Wireless Association Monograph (New Series) No. 1 (1978).
3. Society of Wireless Pioneers, SPARKS BOOK OF THE WIRELESS PIONEERS, Vol. III ([“Tales”] ed. William A. ‘Bill’ Breniman, 1974 at p. 45; E. Jay Quinby, (Commander, USN, Ret.) *Marooned in Paradise*, p.36.
4. Edison Company “Letter” of 1915, an illustrated advertising pamphlet, now in the California Historical Radio Society Radioana collection of the Maxwell Memorial Library at the radio station KRE building in Berkeley, California.
5. D. E. Keith, “Swan Islands, Honduras” <http://www.tarleton.edu/~dekeith/swanislands.html>
A very interesting overview.
6. Thomas Roscoe, K8CX has collected and put on the web the QSL card images, <http://hamgallery.com>. The image of KS4CC comes via K8CX originally from OE1HGW, <http://hamgallery.com/qsl/deleted/SwanIsland/>. KS4CC was the 1968 Swan Island club station, according to Tom Kneitel, note 8 below.
7. See Gerry Dexter, CLANDESTINE CONFIDENTIAL, Universal Electronics, Columbus, Ohio, 1984, Chapter: “Swan Island” at p. 22ff; “Alice Brannigan” (pseudonym), *Radio Swan: At Last, (Most of) the Story*, Popular Communications, June, 1999, p. 8; and also “Alice Brannigan” (pseudonym), *WRUL, The Forgotten ‘Voice of Freedom,’* Popular Communications, June, 1996, p.12; and also Doran Platt, *Swan Island*, Electric Radio, February 2000 [see note 23 below]; see also, e.g., Swan Island DX Association, <http://www.qsl.net/sidxa/history.html>
8. Tom Kneitel [K2AES], *EI Visits Radio Americas*, Electronics Illustrated, July 1968; Tom Kneitel, *Inside the CIA’s Secret Radio Paradise*, Popular Communications, November (Part One), 1985, <http://pl703.pairlitesite.com/Stations/Swan.pdf>
KS4CC as the club station, p. 19
FAA station WSG, p. 19
Pilco Tech Rep flying squad engineers, p. 18, and December (Part Two), 1985, <http://pl703.pairlitesite.com/Stations/Swan-II.pdf>
— navigational beacon callsign SWA, p. 20
9. Gerry Dexter, CLANDESTINE CONFIDENTIAL, note 7 above.
10. E. Howard Hunt, Wikipedia, http://en.wikipedia.org/wiki/E._Howard_Hunt. Hunt was of an admirable old-school view, that of CIA Director Richard Helms, in effect: “when the President told you to do something, you did it and it was legal.” Hunt never understood how he could do what he was trained to do, for the government who trained him to do it, and end up in prison. He was the right guy in the wrong

place at the wrong time. It was little consolation to him as late as 2007 that now nothing is legal.

See generally E. Howard Hunt, *UNDERCOVER*, Berkeley Pub. Corp. & G.P. Putnam & Sons (1974). overrode the Guatemalan national radio from Honduras, p. 100; E. Howard Hunt, *AMERICAN SPY*, Wiley (2007) (adopting a great deal of text from *UNDERCOVER*) radio “channel” (transmitter) in Honduras, p. 75, confusion and despair, p. 77

E. Howard Hunt said in an interview:

“Interviewer: Going back to the Guatemalan army, did it surprise you that they didn’t fight the invasion...?”

“Howard Hunt: Yes. Nobody had anticipated that. Did it surprise me that they did not fight? Very much. We all anticipated an armed struggle - not of great proportions or of long duration, but we did anticipate that, we anticipated some bloodshed. ***when I started seeing the cables coming in, describing what was happening in Guatemala, I was just overjoyed, and I found it hard to believe that there had been no bloodshed, no armed confrontation. Castillo Armas only had about 140 people working for him, a ragtag group if there ever was one, but then we had done the same thing in another part of the world a few years earlier. People don’t have to be in spiffy uniforms: they can ... just so long as they can form a military presence and impress the population.”

(Source George Washington University National Security Archive, <http://www.gwu.edu/~nsarchiv/coldwar/interviews/episode-18/hunt3.html>) Hunt is referring to the CIA’s Iran operations a couple of years earlier.

11. David Atlee Phillips, Wikipedia, http://en.wikipedia.org/wiki/David_Atlee_Phillips. See generally David Atlee Phillips, *THE NIGHT WATCH* (New York,

Atheneum, 1977); this book is almost a CIA -approved “charm offensive” and Atlee founded the Association of Former Intelligence Officers (AFIO) to explain the work they do.

short wave radio popular in Guatemala, p. 41

war won by that radio station, p. 52 kowtowing to United Fruit, p. 53

turnkey radio operation, p. 90

too distant, p. 42

Honduran students, p. 98ff

Radio Americas broadcasting purposelessly, p. 112

12. Stephen Schlesinger and Stephen Kinzer, *BITTER FRUIT – The Story of the American Coup in Guatemala* (Harvard, 1981; 1999) at p. 12. Estimates of the Guatemalan dead in the following decades range as high as 100,000, mostly Mayans.
13. Henry Cabot Lodge, Jr., Wikipedia, http://en.wikipedia.org/wiki/Henry_Cabot_Lodge,_Jr. In retrospect, Lodge was a man of integrity and valor.
14. John Simpson, “Guatemala, Cuba and the Assassination,” Education Forum (UK), <http://educationforum.ipbhost.com/index.php?showtopic=5945>). Like the writing of books in the Book of Ecclesiastes (12:12), there is no end to the conspiracy theories of the Kennedy assassination, most involving CIA personnel including E. Howard Hunt.
15. United Fruit Company, Wikipedia, http://en.wikipedia.org/wiki/United_Fruit_Company
16. Operation PBSUCCESS, Wikipedia, http://en.wikipedia.org/wiki/Operation_PBSUCCESS
17. Don Moore, *The Clandestine Granddaddy of Central America*, Monitoring Times, April, 1989, and <http://www.pateplumaradio.com/central/guatemala/vozlib.html>; this page of Moore’s PateplumaRadio website presents much of David Atlee Phillips’ chapter on the Guatemalan CIA operations without attribution but also a great deal of other information. Moore later suggested to the author that his

- information that the Swan Island CIA transmitter was a back-up only comes from BITTER FRUIT (above, note 12).
18. Personal communication to the author.
19. DX Communication website <http://dxcommunication.net/ambroadcastband.htm>
20. Operation PBHistory, Wikipedia, http://en.wikipedia.org/wiki/Operation_PBHistory
21. "Swan Song" by William L. Magnuson, who had served in the Navy on Swan Island in 1955 (from a collection of student essays from the 1950s), http://libsysdigi.library.illinois.edu/oca/Books2008-09/greencaldron/greencaldron2730univ/greencaldron2730univ_djvu.txt
22. George T. Damoff in WeatherMatrix: <http://www.weathermatrix.net/education/swanisland/>
23. Doron Platt and Michael D. Stanley in WeatherMatrix: <http://www.weathermatrix.net/education/swanisland/> and Gerry Dexter, CLANDESTINE CONFIDENTIAL [note 7 above] and Tom Kneitel [note 8 above].
24. This document can be found on the CIA website. <http://www.foia.cia.gov/search.asp>; search for "Brief History of Radio Swan" which produces a Table of Contents of an analytical history of the Cuban operations and planning of 1961. That table says "History of Radio Swan" at p. 21, but there is multiple pagination within the document. The History is found at page 131 ff.
25. The larger document at note 24 above discloses CIA use of WRUL as well as Radio Swan for anti-Castro broadcasting and programming.
26. "Alice Brannigan" (pseudonym), WRUL, The Forgotten 'Voice of Freedom,' [note 7 above].
27. Pirate Radio in Central America..., Wikipedia, http://en.wikipedia.org/wiki/Pirate_radio_in_Central_America_and_Caribbean_Sea)
28. U.S. National Oceanic and Atmospheric Administration (NOAA), History, Hall of Honor, [1975], http://www.history.noaa.gov/hallofhonor/lifesaving_1955-2000nws.html)
29. Gerry Dexter, CLANDESTINE CONFIDENTIAL, [note 7 above, Chapter: "Swan Island" at p. 28ff].
30. See, e.g., PLANE SUPPLYING CONTRAS CRASHES; 11 BELIEVED KILLED IN NICARAGUA; PLANE STRUCK BY MISSILES, by Bernard E. Trainor, Special to the New York Times; Published: Monday, January 25, 1988, and <http://www.nytimes.com/1988/01/25/world/plane-supplying-contras-crashes-11-believed-killed-nicaragua-plane-struck.html>
31. The Honduran officer is quoted in the Sandinista publication and digital archive, *Envio* Magazine: <http://www.envio.org.ni/articulo/2707>)
32. Former CIA officer Kenneth C. Stahl, letter to Senator Lauch Faircloth, February 26, 1998 in <http://cryptome.org/cia-gripe.htm>)
33. GACIAC [Guidance and Control Information Analysis Center] Bulletin Volume 19 No. 3, <http://wstiac.alionscience.com/pdf/GACV19N3.pdf>

ACKNOWLEDGEMENT

I am grateful to the late E Howard Hunt for telling me about otherwise unpublished aspects of the CIA operations on Swan Island.

APPENDIX

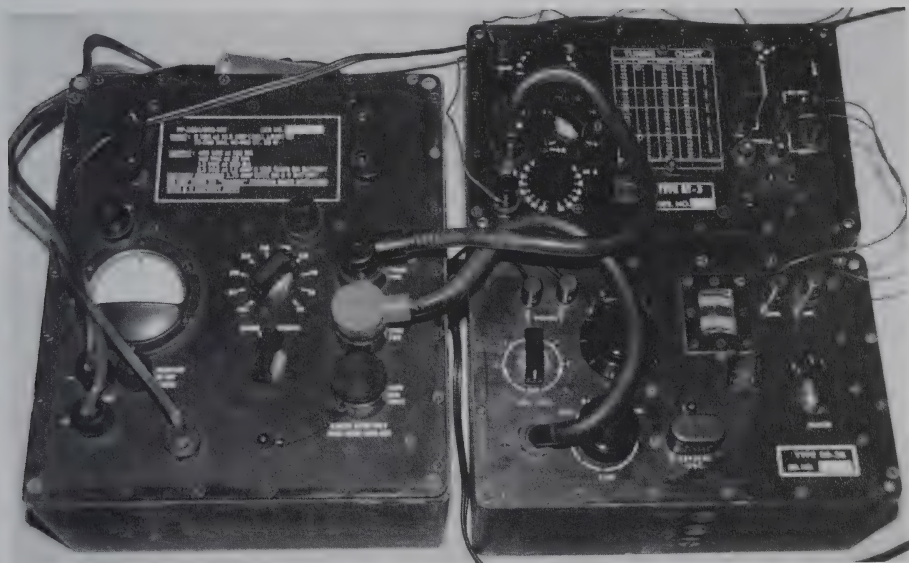
The CIA provided to its 1954 Guatemalan "insurgents" tactical radios such as the RS-1 High Frequency Transceiver, with its interconnected transmitter, receiver and power modules.

"The RS-1 could be considered the 'flagship' of cold-war U.S. clandestine radios. It's development started in 1948; and it was used by the Agency for 12-15

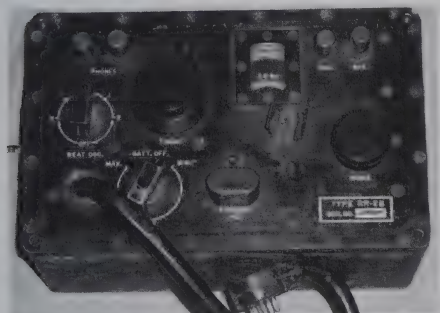
years, and by the Army for several additional years.... the RS-1 was valued long afterward for being functional and reliable," according to Spy Radios historian Peter McCollum, at [www.militaryradio.com](http://www.militaryradio.com/spyradio/rs1.html).

www.militaryradio.com/spyradio/rs1.html.

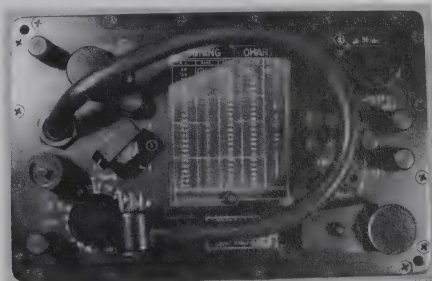
The photos of the set and the receiver are from the McCollum website of a radio in his collection. Those of the transmitter and its interior are photos from Dennis



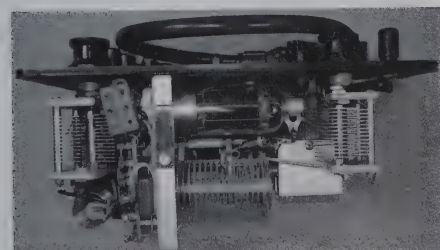
RS-1 full set



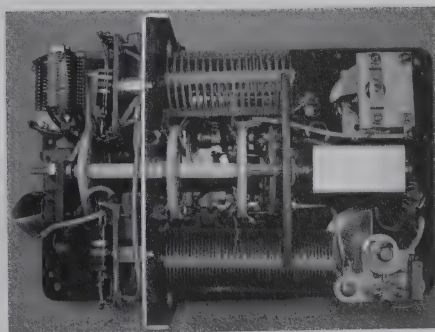
RS-1 receiver rr-2b



RS-1 transmitter rt-3



RS-1 transmitter interior (1)



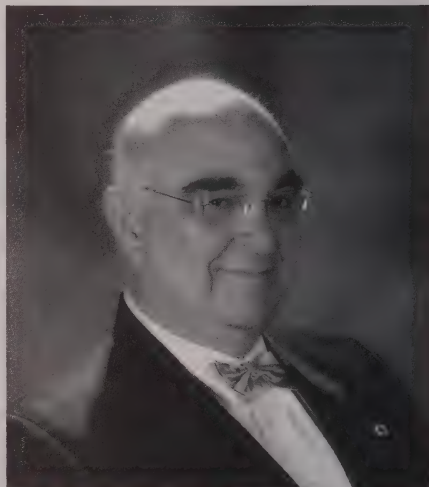
RS-1 transmitter interior (2)

Monticelli, AE6C, CHRS, of a radio in his collection. All photos used by permission.

ABOUT THE AUTHOR

Bartholomew (Bart) Lee, K6VK, xKV6LEE, WPE2DLT, is a long time member of AWA and the California Historical Radio Society, for whom he serves as General Counsel Emeritus. He has enjoyed radio and radio-related activities in many parts of the world, in the last year in Greece and the UK. Radio technology and history have fascinated him since he made his first crystal set with a razor blade and pencil lead more than 50 years ago. He is especially fond of those sets of which it is said: 'Real Radios Glow in the Dark.' Bart is a widely published author on legal subjects and most recently on the history of radio. He has, in many forums, including most recently the annual meeting of the American Vacuum Society, written about and lectured on early radio technology, radio intelligence activities ('episodes in the ether wars') from 1901 into the latter 20th Century, wireless telegraphy especially Marconi's early work, wireless developments in California and the West Coast since 1899, short wave radio, radio ephemera including radio stamps, and radio in emergency and disaster response. Since 1989 he has made some 20 presentations to the AWA conferences on his research interests including the development of television in San Francisco in the 1920s. The AWA presented its Houck Award for documentation to him in 2003 and the California Historical Radio Society made its 1991 'Doc' Herrold Award to him in connection with his work for the Perham Foundation Electronics Museum. In 2001,

during disaster recovery operations in New York after the '9/11' terrorist enormity, he served as the Red Cross deputy communications lead from September 12 to September 21, (the 'night shift trick chief'). He has served as the Liaison Officer for the San Francisco Auxiliary Communications System (ACS – RACES) and as an ARES Emergency Coordinator. He presently serves as an ARRL Government Liaison and Volunteer Counsel. Bart is a litigator by trade, having prosecuted and defended cases in both state and federal court. He also taught Law & Economics for 20 years, including the economic history of telecommunications. He is a graduate of St. John's College (the 'Great Books School') and the University of Chicago Law School. Bart's son Christoffer Lee is also a licensed amateur radio operator and is now finishing law school. Bart invites correspondence at: KV6LEE@gmail.com



Bart Lee. Photo by Paula Carmody, taken in Indonesia; copyright Bart Lee 2009.

SCR-54/A (BC-14/A) Radio Receiver Sets for Artillery Spotting

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ABSTRACT

The BC-14A boxes from the SCR-54A radio receiving sets manufactured by at least four different contractors are the most widely collected of all World War One radios. The colorful method by which these sets were used to communicate with aircraft for artillery spotting missions during World War One is summarized. Next, the evolution of the AR-4, SCR-54 and SCR-54A receiving sets based on the French A-1 receiver is documented. The evolution of the companion AR-5 vacuum-tube detector and SCR-55, DT-3 and DT-3A variants is also documented. Finally, a primer for identifying each of the seven known variants of the BC-14A is provided. The primer can be used by the discriminating collector not only to identify each variant, but also to identify surreptitious alterations thereof—something very common among these sets.

The year was 1917 and the United States had just entered World War One on the side of the French and British allies by declaring war on Germany on April 6. The U.S. was woefully unprepared to go to war in Europe, and nowhere was this more evident than with radio communication. The Signal Corps had developed its field-portable wireless systems based on its experience with warfare in Mexico which presented conditions very different from those found on the Western Front. The Signal Corps had two basic field-portable wireless systems, both with relatively high radiated powers—a mule-borne radio pack set and a field-wagon set.¹

Even before the American Expeditionary Force (AEF) began to arrive in Europe, it was determined that these radio sets would have only limited application, and after they arrived it was determined that they often interfered with the radios already in use by the French and British. Thus, the U.S. was faced with the need to design a whole new set of radio systems. Indeed, by the date of the armistice, Nov. 11, 1918, the U.S. had worked on 75 types of sets with different SCR numbers—of which 25 were in quantity production.² The age-old adage that the military prepares well for the last war proved once again to be true.

According to Captain G. Francis Gray who was in charge of radio development by industry for the Signal Corps during World War One, the most important and extensive use of radio during World War One was for directing artillery fire from airplanes.³ Of the 75 sets assigned different SCR numbers under development by the U.S. during the war, at least seven sets (not including variants) were specifically designed for artillery spotting from airplanes: the SCR-54, SCR-55, SCR-64, SCR-65, SCR-73, SCR-100, and SCR-113. Of these sets, four (plus variants) were produced in quantity—the SCR-54, SCR-55, SCR-65, and SCR-73.

The SCR-54 and its variant SCR-54A were

radio receiving sets based on the French A-1 receiver which had been in use by the French in the field for several years before the U.S. entered the war. The SCR-55 was a new vacuum-tube detector set which was later reclassified from a "complete set" to an "equipment type" (terms which are defined later) and assigned the designation DT-3 detector equipment. A later variant was assigned the designation DT-3A. The SCR-65 and its variant SCR-65A were adjustable spark gap transmitter sets based on the British Sterling Buzzer Fire Control Set,⁴ both of which were battery operated. These sets were used primarily for training purposes. The SCR-73 and its variant SCR-73A were transmitter sets based on the French Type "Y" set,⁵ both of which were operated by an alternator driven by a small air fan (similar to a propeller blade). This set with higher radiated power than the SCR-65/A was used in combat for artillery spotting. The SCR-64 was the predecessor of the SCR-73, and the SCR-100 and SCR-113 were derivatives of the SCR-73 that were not produced in quantity.

Three of the four complete SCR sets and variants were designed such that the transmitter or receiver components were contained in wood boxes assigned "BC" designations. These boxes which are highly prized by collectors today are the primary surviving remnants of the complete sets—most of the antennas and other ancillary equipment having long ago disappeared. The BC designations for the five boxes associated with the complete sets are given here in parenthesis after the respective complete set designation for which they were designed: SCR-54 (BC-14), SCR-54A (BC-14A), SCR-55 (BC-19), SCR-65 (BC-15) and SCR-65A (BC-15A). A variant of the complete SCR-55 set

and its BC-19 box were assigned the designations SCR-55A and BC-19A but were never produced in quantity.

The BC designations appeared on the nameplates of only two of these sets—the SCR-54A receiver box designated BC-14A, and the SCR-65A transmitter box designated BC-15A. The designations BC-14, BC-15 and BC-19 never appeared on nameplates of their respective boxes. The SCR-73 and SCR-73A transmitters were housed in stream-lined casings mounted on the wing or structure and did not have boxes with a BC designation.

The focus of this article is on the evolution of the SCR-54/A crystal receiver sets, and the SCR-55 and DT-3/A vacuum-tube detectors. Much has already been written about the SCR-65/A and SCR-73/A transmitters used with these receivers, and the reader is referred to those articles—not the least of which is one appearing in a recent issue of the *AWA Review* by Larry Babcock covering World War One radio equipment installed on airplanes.⁶ Perhaps more has been written about the SCR-73/A sets than any other World War One transmitter,⁷ and although there are almost as many articles addressing the SCR-65/A transmitters, they are generally shorter and less authoritative.⁸

The remainder of this article is divided into three parts: 1) the methods used by the allies in World War One to accomplish artillery spotting with one-way wireless code communication from the airplane to the ground, supplemented by semaphore communication from the ground to airplane, 2) the evolution of the SCR-54/A crystal receivers, and the SCR-55 and DT-3/A detectors developed by the Signal Corps for artillery spotting during World War One,

and 3) a primer on collecting the BC-14A—the most common and widely collected of all the World War One artillery-spotting radios available to the collector today. The information provided in this part will be most useful to the collector to avoid common pitfalls in collecting these receivers.

ARTILLERY SPOTTING WITH RADIO TELEGRAPHY FROM AIRPLANES

At the time the U.S. entered the war, two-way radio communication between Allied military aircraft and the ground had not yet been perfected. Code communication from airplanes to ground had been achieved with spark transmitters aboard the aircraft and crystal sets on the ground—both with and without vacuum-tube detectors and amplifiers. However, because radio reception with a crystal set on the airplane was deemed to be impractical, the Signal Corps began the development of a vacuum-tube receiver in 1917 with a size and weight appropriate for aircraft platforms. Production models of the resulting receiver designated SCR-68 did not begin to arrive in France until mid-1918.⁹ These early production units were far from perfect and were still undergoing test and evaluation with attendant modification

right up to the time of the armistice.¹⁰ There is virtually no mention of their use in combat during World War One for artillery spotting.

Lacking tactical use of two-way radio communication between aircraft and ground at the start of the war, the French and British had developed an interesting and colorful method of communicating from the ground to the artillery spotter in the airplane—the same method adopted by the AEF after arriving at the front. Communication was accomplished by a kind of semaphore system using white strips of cloth approximately six feet long by one foot wide which were laid on the ground in “panel fields” to form symbols and letters. The symbols formed by cloth strips of these dimensions were readily visible and distinguishable from the air up to altitudes of approximately 3,000 feet. Examples of panel markers used to communicate with airplanes are shown in Fig. 1.



Fig. 1. Lacking the means to communicate by radio from the ground to artillery-spotting aircraft during WWI, Signal Corps personnel laid out cloth strips to communicate visually with these aircraft. (The U.S. Air Service in World War I, V. 2, p. 299)

The general method used for artillery spotting and fire control during World War One was succinctly described in the *Report of the Chief Signal Officer* dated 1919:¹¹

"The work of the operating personnel was to receive from airplanes the corrections sent down by observers. The procedure was as follows: The observer when he first went in the air sent down his call, which was received by one of these operators and telephoned out to the panel field, where the panel 'Understood' was laid out. The observer then inquired by code if battery was ready. The panel 'Battery ready' was then laid out. Then the observer placed himself in proper position to observe the target on which the battery was supposed to be, being located near the panel field. At the same time the panel 'Battery has fired' was laid out. The observer then sent down the necessary corrections to alter the range or deflection and the process was repeated.

"Work in the field consisted of having a detail of soldiers lay out the proper panels in a locality which could be readily seen by observers in the air. It also consisted of having personnel at the starting line, in order to give final instructions to the observers before they left the ground, as many of the observers going up were making their first trip on a radio mission. It was found necessary to give them this instruction in order to obviate possible failures."

Vignettes of the artillery spotting process by airplane recalled by many participants are scattered over more than fifty pages of a four volume set entitled *The U.S. Air Service in World War I*,¹² from which the following descriptive material focusing on the use of radio was extracted. First, the

spotter aircraft would check radio function before leaving the ground and then over-fly the artillery battery for which it was spotting to make contact with the wireless operator. After making contact, the airplane then flew over enemy territory executing circles or figure eights over the target at altitudes between 4,000 to 6,000 feet. Spotters observed the location of artillery fire relative to the target and then headed back to their artillery battery to transmit the correction messages such as "right," "left," "too short," and so forth.

Because the radiated power from the airplane was limited and the radiation pattern of the trailing wire antenna used on World War One aircraft was forward-directed,¹³ the aircraft was usually pointed towards the friendly artillery battery during transmissions to maximize the power density reaching the receiver, thereby increasing the probability that messages would be received and understood. An astute radio operator stationed at an artillery battery could easily identify a plane headed directly for the battery versus one traversing the front line by the rapid rate of increase of signal as the plane approached.

Transmissions to the ground stations were to be made at distances greater than two kilometers from the receiving station to limit the signal strength, thereby avoiding serious interference with other wireless communications. Transmissions from multiple airplanes were also distinguished by call signs, differences in wavelengths and varying tones of spark emissions. For example, the SCR-73 spark transmitter aboard U.S. aircraft used for artillery spotting applications was designed to transmit nine wavelengths and five tones, resulting in a combination

of 45 distinctly different signals. By observing all the rules to avoid interference, approximately five spotter airplanes could operate simultaneously along each kilometer of the front line.

Each time after signaling corrections for artillery fire, the plane would fly back over the artillery battery to receive information from the battery in the form of panel messages. The panels were to be waived about at just the right time to attract the attention of the observer. During training it was emphasized "that the panels when laid out must be 'living,' that is to say, continually moved about or agitated, and not merely unrolled and left lying."¹⁴ Of course, the panels were also to be laid out in such a location and for such a period of time that the enemy would not detect the location of the receiving station.

Unfortunately, it was not always possible to signal the friendly aircraft with panels while at the same time hiding them from enemy aircraft. Consider the exploits of a young and inexperienced Australian wireless operator, Alec Griffiths, assigned to the task of artillery spotting on the Western Front during World War One as recounted by Robert Crack in his book *Until a Dead Horse Kicks You*.¹⁵ This book gives a very dramatic view of how wireless operators fared on the Western Front during World War One.

"After his [Alec Griffiths'] meal he was briefed by the battery commander and informed that he was there to assist in conducting a shoot. This much Alec had already guessed. He was ordered to set up his equipment outside and then return to the dugout. He'd just sat down on his soaking wet kit-bag when he was ordered outside again. He managed to establish

contact with the aeroplane, but the signals were very weak. There was a lot of interference because all sorts of wireless sets were being used up and down the line—by Fritz [the Germans] as well. In a crystal set there were no valves or anything as elaborate as that, just a finicky task of adjustment. Within moments of establishing contact, the RE8 flew almost directly overhead. It headed towards some target or other in the distance. A few minutes later, Alec received the pilot's first signal and passed it on to the battery commander.

"Alec had positioned his wireless set and aerial mast too close to the adjusting gun. CRACK! The gun fired, blasting the point [cat's whisker] off the crystal and rocking Alec as well. Despite its being a significant part of his job, he had received no prior training in working with live artillery, and it would be weeks before he grew accustomed to being so close to the guns when they fired.

"The shoot continued. Alec grew tired racing around laying out white strips of canvas on the spongy mud. As he was doing this he wondered why the battery even bothered with camouflage. In the near distance a red enemy plane flew towards them, performed a figure-of-eight, and then flew back to where it had come from. Alec's canvas strips were easily the most visible things in the entire sector and before long the Germans were doing the same thing to Alec's battery as it was doing to them.

"First a shell landed a fair way off. Then the red plane returned. Another shell landed quite a bit closer. This continued until they were at the receiving end of a salvo. The whine of approaching shells teased Alec's ears, before the sound of explosions filled them."

It is clear from this vignette that

the duties of wireless operators put them in a precarious position, particularly when they had to leave the relative safety of the dugout to place signal patches on the ground—many times while the battery was on the receiving end of an artillery barrage. It was said that the attrition rate of wireless operators on the front lines in World War One approached fifty percent. To find out what happened to our courageous wireless operator, Alec Griffiths, it will be necessary obtain a copy of this book—a must-read for anyone interested in this subject.

EVOLUTION OF THE SCR-54/A RECEIVERS AND VACUUM TUBE DETECTORS

The U.S. was in the war for only 19 months before the armistice took effect on Nov. 11, 1918, severely limiting the time for the Signal Corps to develop, manufacture, test and deliver entirely new radio equipment to the front for use in combat. As a result, very little of the radio equipment designed and manufactured under contract to the Signal Corps during the war arrived in quantity in Europe until October 1918, just before the armistice.¹⁶ In the interim, the U.S. purchased much of the radio equipment used by the AEF from its European allies, and since the AEF operated in the French sector, much of it was purchased from France. For example, the French A-1 crystal set was purchased by the U.S. in quantity from France and used by the Signal Corps to receive corrections from airplanes for aiming artillery on the Western Front. Its use by U.S. troops was memorialized by a photograph appearing *The Wireless Age* showing Signal Corps radio operators receiving signals with an A-1 re-

ceiver connected to a French 3-Ter amplifier.¹⁷

Shortly after the U.S. Congress declared war on April 6, 1917, the U.S. extended an invitation to both the French and British to send commissions to the U.S. to acquaint the Signal Corps on the state of the art of communications then in use by the Allies, and to provide suggestions on where improvements were needed. A French commission arrived in this country in June of 1917 with samples of much of the radio equipment used by the French army. On July 2, 1917, the Radio Division formed by Brig. Gen. George O. Squier,¹⁸ Chief Signal Officer (see Fig. 2), was tasked to handle radio matters for both the Aviation Section and the Signal Corps.

Because the AEF was operating in the French sector, it was necessary for the radio frequencies of U.S. equipment to correspond as closely as possible to those of the



Fig. 2. General George O. Squier, Chief Signal Officer of the Signal Corps and Chief of the Army Air Service, contributed greatly to the development of radio both during and after WWI.

French. A wave-length schedule was prepared and forwarded to Washington on March 27, 1918 containing the following information:¹⁹

- Trench radios: 100-150 meters
- Spark set fire-control for airplanes: 200-550 meters
- CW long-range fire-control for airplanes: 550-750 meters
- CW for infantry contact (airplanes, tanks, brigades): 600-1,000 meters
- CW for division and corps: 1,000-1,350 meters
- CW for armies: 1,350-1,800 meters

It was not until April 26, 1918—almost a year to the day after the U.S. entered the war—that a letter was sent to Washington giving the complete new wave-length schedules with requisitions for monthly deliveries of certain radio equipment. It would appear that requisitions for large orders of receivers did not occur until after that date. The list of contracts in excess of \$100,000 awarded by the Signal Corps for radio equipment between April 6, 1917 and June 1, 1919 to U.S. contractors contains few if any large contracts with award dates prior to June of 1918.²⁰

The radio receivers manufactured by the Signal Corps for artillery spotting during World War One are listed in chronological order in Table 1 with the following information, most of which was taken from nameplates found on examples of these sets: contract order number, date, hardware designation, and manufacturer. The Signal Corps letter and number designations found on the nameplates appear in the left column under “Hardware.”

Evolution of the SCR-54/A Receivers. The SCR-54A receiving

set developed for the AEF by the Signal Corps for artillery spotting was based on the French Type A-1 crystal receiver designed in 1915. The A-1 was already in use for various applications including artillery spotting when the AEF arrived on the Western Front during World War One. The U.S. design based on the A-1 receiver went through several iterations in 1917. The first was designated the AR-4 and the second was designated the SCR-54—which were virtually identical to each other, and only modestly different from the original French A-1 design. The final version of this set designated the SCR-54A, which went into full production in mid-1918, had the same general appearance as its predecessors but was different in several important respects. Most notably, it had a panel-mounted crystal detector in lieu of two detachable detectors secured by binding posts, and a panel-mounted buzzer (used to find sensitive points on the crystal detector) in lieu of a buzzer permanently mounted in the box lid.

French A-1 Crystal Receiver: The A-1 crystal set developed for the French Army circa 1915 was described in the Signal Corps Bulletin No. R-6 entitled *Receiving Set A-1 (French)* dated Feb. 16, 1918. An example of the A-1 receiver which was used as the basis for the design of the SCR-54 is shown in Fig. 3. The existence of an earlier French instruction manual entitled *Note sur l'emploi du récepteur radiotélégraphique Modèle Télégraphie Militaire 1915 Type A* [*Instructions on the Use of the Radiotelegraph Receiver Model Military Telegraphy 1915 Type A*] suggests an earlier French Type A model may have preceded the Type A-1. However, the schematic diagram appearing in the French Type A manual, reproduced here

Table 1. Crystal radio receivers and vacuum-tube detectors manufactured under contract to the Signal Corps during WWI for purposes of artillery spotting (listed in chronological order of contract award)

Order No.	Date	Hardware Designation			Manufacturer
		Nameplate	Other	Type	
9127	Summer, 1917	AR-4	None	Receiver	Western Electric
Unknown	Summer, 1917	AR-5	None	Detector	See text
W-40283	Fall, 1917	SCR-54	BC-14	Receiver	Western Electric
W-40283	Fall, 1917	SCR-55	BC-19	Detector	Western Electric
40723	Dec. 26, 1917	DT-3	See text	Detector	Connecticut Tel.
Unknown	Unknown	DT-3A	BC-19A	Detector	Unknown
40724	Dec. 27, 1917	SCR-54	BC-14	Receiver	Liberty Electric
40725	Dec. 27, 1917	SCR-54	BC-14	Receiver	De Forest
41874	March 12, 1918	SCR-55	BC-19	Detector	De Forest
42730	June 21, 1918	BC-14A	SCR-54A	Receiver	General Radio
130008	July 8, 1918	BC-14A	SCR-54A	Receiver	General Radio
130009	July 11, 1918	BC-14A	SCR-54A	Receiver	De Forest
130018	1918	BC-14A	SCR-54A	Receiver	Marconi
130019	July 16, 1918	BC-14A	SCR-54A	Receiver	Liberty Electric
130339	Sept. 12, 1918	BC-14A	SCR-54A	Receiver	De Forest
130453	Oct. 23, 1918	BC-14A	SCR-54A	Receiver	Liberty Electric



Fig. 3. The French A-1 crystal set similar to this copy made by Mildé Fils & Co. was used as the basis for the design of Signal Corps receivers used for artillery spotting.

as Fig. 4, is identical to the one in the Signal Corps Type A-1 manual, so the differences between the two versions—if, in fact, there was an earlier version—must have been cosmetic.

This schematic diagram is worthy of note for several reasons. First, the schematic is arranged according to the physical layout of the components and interconnecting wires, and therefore would have served as a wiring diagram,

as well. Second, the symbols used for the electrical components are more representative of the physical appearance of each rather than standard electrical symbols of the day. An interesting example is the pair of French headphone jacks represented by two adjacent rectangles appearing on the right side diagram—clearly evocative of the actual jacks shown in Fig. 5. It is also notable that the schematic diagrams of the A-1 derivatives

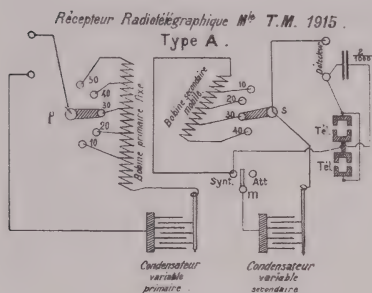


Fig. 4. The existence of a French instruction manual describing the "Modèle Télégraphie Militaire 1915 Type A" crystal receiver with the schematic diagram shown here suggests an earlier French Type A model may have preceded the Type A-1.

designed by U.S. contractors also followed this same scheme, as did those of the companion vacuum-tube detectors—even though they were not based on a French design.

The A-1 was made by a relatively large number of different French manufacturers including well-known companies such as Ducretet and SFR (Société Française Radioélectrique), and relatively obscure companies such as Baudouin, Gaumont, L. Bardon,

and Mildé to name a few. While the "Type" designation of this set was generally expressed as "A-1" in both the literature and on the nameplates of many sets, it was also expressed in other ways on nameplates—for example, as "A1" without an intervening dash by L. Bardon and Gaumont, and even as "A¹" by Mildé where the numeral "1" appeared as a superscript (see Fig. 6).

The A-1 receiver had a two-circuit tuner in which the antenna was isolated from the detector by a variable induction coil (i.e., variometer) which could be used to control the degree of coupling. The inductance in both the primary and secondary circuits could be adjusted by the two tap switches at the top of the panel shown Fig. 7. Each tap was labeled by a number denoting the number of turns remaining in the primary or secondary circuit for that tap. The positions of the tap switches controlled the general operating wavelength of the set, while the two variable capacitors across the primary and secondary coils could be varied for fine tuning.

Pointers on the capacitor knobs were calibrated from 0 to 90 such that the plates were fully open at 0 and fully meshed at 90. The capacitor across the secondary was initially switched out of the circuit for broad tuning to acquire stations, and then switched back into the circuit for sharper tuning to eliminate extraneous stations operating on nearby wavelengths. The degree of cou-

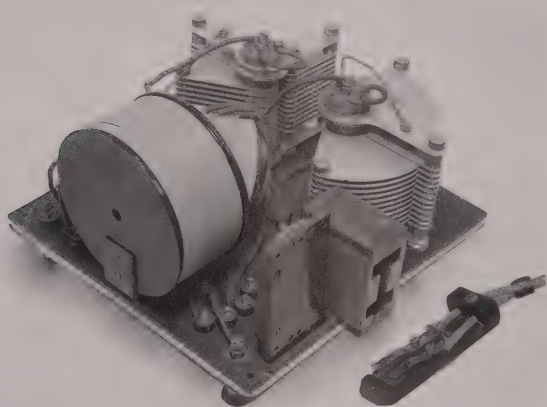


Fig. 5. An interior view of the A-1 receiver reveals an unusual double headphone jack used by the French, shown here with the companion plug in the foreground. (Mike Katzdorn and Eric Wenaas collections).



Fig. 6. The A-1 designation was expressed in several different ways on the nameplates of the French sets including the superscript form A¹ used by Mildé Fils & Co.

pling from primary to secondary circuits could be controlled by the position of the variometer. Interfering stations with weaker signals could be reduced by adjusting the variometer to decrease the degree of coupling. All subsequent variants designed by the U.S. used the same basic circuit and panel layout.

The A-1 came with a buzzer box positioned on the right side of the lid to aid in adjusting the

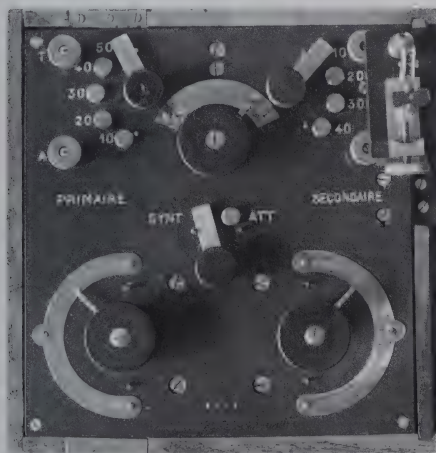


Fig. 7. The numbers next to the two tap switches on the panel of A-1 receivers denoted the number of turns in the primary and secondary coils connected to the respective taps.

crystal detector and receiver in the absence of radio signals. The buzzer box contained a mechanical buzzer connected to a tank circuit consisting of a capacitor and flat coil with multiple taps which could be adjusted to achieve preselected wavelengths by means of the tap switch knob on the front of the box. The buzzer box shown in Fig. 8 was designed with 19 preselected wavelengths which, according to the calibration table provided, ranged between 100 and 490 meters.

AR-4 Crystal Receiver: Samples of the French A-1 set were sent to the U.S. in the summer of 1917 where it was copied with minor modifications by the Western Electric Co. and assigned the model number AR-4 which appeared on the nameplates, an example of which is shown in Fig. 9. The AR-4 receiver shown in Fig. 10 was similar in appearance to the French A-1 set—the most noticeable difference being the arrangement of the buzzers in the lids. The French buzzer was contained in a removable box and used a tunable tank circuit to radiate selected

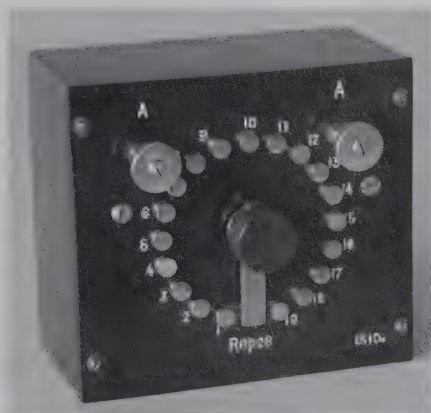


Fig. 8. The removable buzzer box with an adjustable tank circuit for radiating specific wavelengths was used to find a sensitive spot on the crystal detector and tune the radio in the absence of other radiated signals.

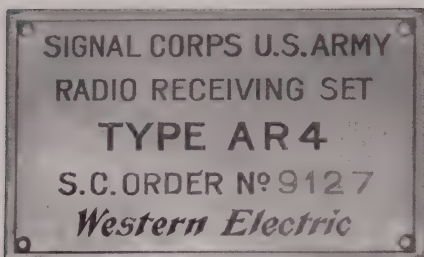


Fig. 9. This nameplate was affixed to an AR-4 receiver, the first U.S. model made by Western Electric for the Signal Corps based on the French A-1 receiver. (Jack Weatherby collection)

preset wavelengths, whereas the SCR-54 buzzer was permanently integrated into the lid and did not have a tuned circuit. The output of the buzzer on the AR-4 was made accessible by a Fahnestock clip where a short wire could be used to connect the buzzer output to the antenna input terminal (see Fig. 11).

The AR-4 receiver circuit was virtually identical to that of the A-1 receiver—the only noticeable difference being the number of turns



Fig. 10. The American-made AR-4 was similar in appearance to the A-1 with the notable exception of the non-tunable buzzer which was permanently mounted in a compartment on the lid of the box. (Mike Katzdorn collection)

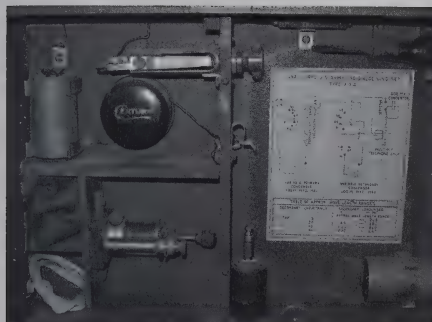


Fig. 11. The output of the buzzer mounted in the lid of the AR-4 was accessible from a Fahnestock clip where a short wire could be used to connect the buzzer output to the antenna input terminal. (Mike Katzdorn collection)

on the primary and secondary coils as evidenced by slightly different numbers appearing next to the coils in the schematic diagram (see Fig. 12). The numbers engraved on the panel next to the two tap switch switches were also changed to agree with the new numbers of turns used for each tap.

Samples of the AR-4 were sent to the AEF in October 1917 for

test and evaluation, at which time it was determined that the performance of the AR-4 was about equal to the A-1, although certain changes of a mechanical nature were desired. Before these changes could be incorporated into the design, the Signal Corps contracted for three productions runs of a set designated SCR-54, consistent with a new nomenclature system.

The new nomenclature system instituted by the Signal Corps during the second half of 1917 was detailed in the Signal Corps *Storage Manual* dated 1920.²¹ According to this manual, the SCR designation stood for “*Signal Corps radios sets, complete*”—that is to say, a complete radio set such as a receiver with its antenna and other ancillary equipment required to function. The complete set was composed of “equipments” which were assigned one- or two-letter designations—for example, “BC” which was used for “*set boxes, apparatus boxes, carrying boxes, cabinets, outlet boxes, chests and the like.*”

SCR-54 Crystal Receiver (BC-14): The SCR-54 was one of the first—if not the first—radio to be mass produced by the Signal Corps during World War One. The Signal Corps contracted with the Western Electric Co. circa October of 1917, the De Forest Radio Telephone and Telegraph Co. on Dec. 27 1917, and the Liberty Electric Corp. on Dec. 27, 1917 to manufacture a number of SCR-54 receiver sets. Evidence of these contracts and award dates is provided by the three nameplates shown in Fig. 13. The use of the SCR-54 by U.S. Signal Corps operators during World War One is memorialized in a photograph on the cover of the January, 1919 issue of the *Wireless Age* picturing the SCR-54 with a French Model No. 3-Ter amplifier, reproduced

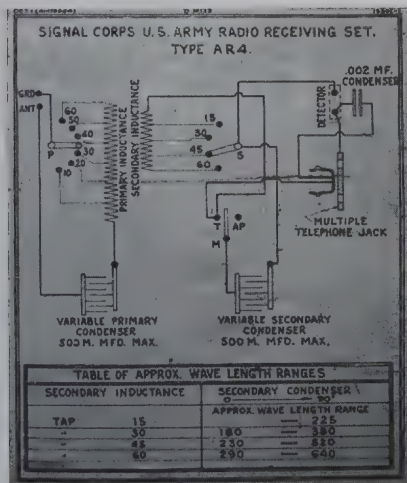


Fig. 12. The AR-4 receiver circuit was virtually identical to that of the A-1 receiver with the only noticeable difference being the number of turns on the primary and secondary coils. (Mike Katzdorn collection)

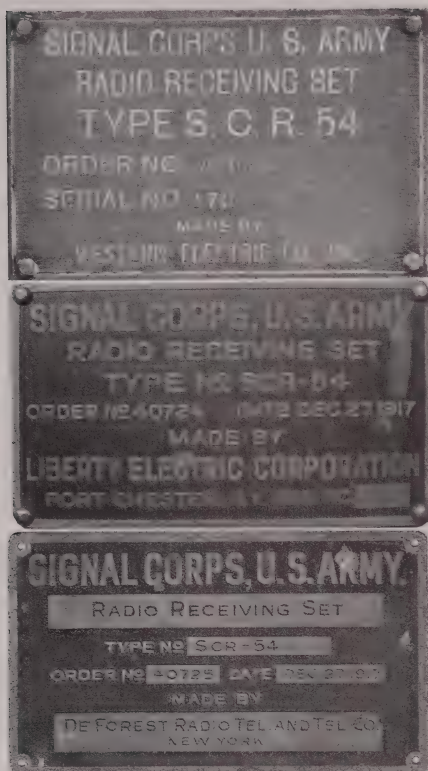


Fig. 13. The nameplates shown here provide evidence of the three contracts awarded to Western Electric, De Forest and Liberty Electric for the manufacture of the SCR-54. (collections of Eric Wenaas, Alan Douglas, and Mike Katzdorn)

here as Fig. 14.²²

The complete SCR-54 receiving set consisted of two equipment types, a Type RC-1 receiver and a Type A-2 antenna.²³ The RC-1 receiving equipment consisted of a box Type BC-14 and other ancillary apparatus including box straps, two telephones (i.e., headsets), two different types of detachable crystal detectors (see Fig. 15), spare crystals and cat's whiskers, batteries, a screwdriver, and 30 ft. of wire.

Despite this numbering system officially adopted by the Signal Corps, the designation on the nameplates affixed to the receiver



Fig. 14. The use of the SCR-54 receiver in WWI was memorialized on the cover of "The Wireless Age" by this photograph of Signal Corps operators receiving signals with the SCR-54 connected to a French 3-Ter vacuum-tube amplifier. ("The Wireless Age", January, 1919 cover)

box was SCR-54—not RC-1 or BC-14. The receiver portion of this set is generally referred to today as BC-14 rather than the correct RC-1 designation which appears in early Signal Corps documents. To avoid confusion, the receiver portions of the SCR-54 and SCR-54A sets will be referred to hereafter as BC-14 and BC-14A respectively, the designations in common usage today.

With the exception of certain cosmetic features such as the style of knobs, the BC-14 box and panel

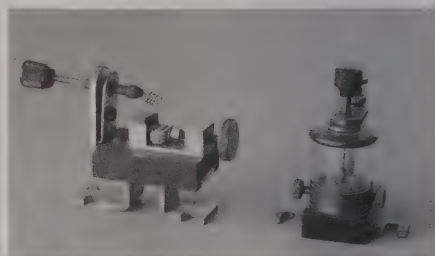


Fig. 15. Two detachable crystal detectors were provided with the SCR-54, one with a glass cylinder to protect against inclement weather and other airborne contaminants.

for the SCR-54 receivers were virtually identical to those of the AR-4 (see Fig. 16). In addition, the schematic diagram sheets attached to the lids of the SCR-54 and AR-4 sets made by Western Electric were also identical (except for the model designations), so any differences that might exist would have been mechanical in nature and very minor.

According to a report published in 1919 at the request of the then Assistant Secretary of War,

the number of complete SCR-54 sets produced through Nov. 11, 1918, the date of the armistice, was 7,752.²⁴ Given the relatively few number of SCR-54 receivers on the market today—both in absolute numbers and numbers relative to the SCR-54A receiver (BC-14A)—one can only wonder if the number reported in this reference also included the SCR-54A/BC-14A variant. This conjecture is suggested by the fact that there was no mention of any “A” variants

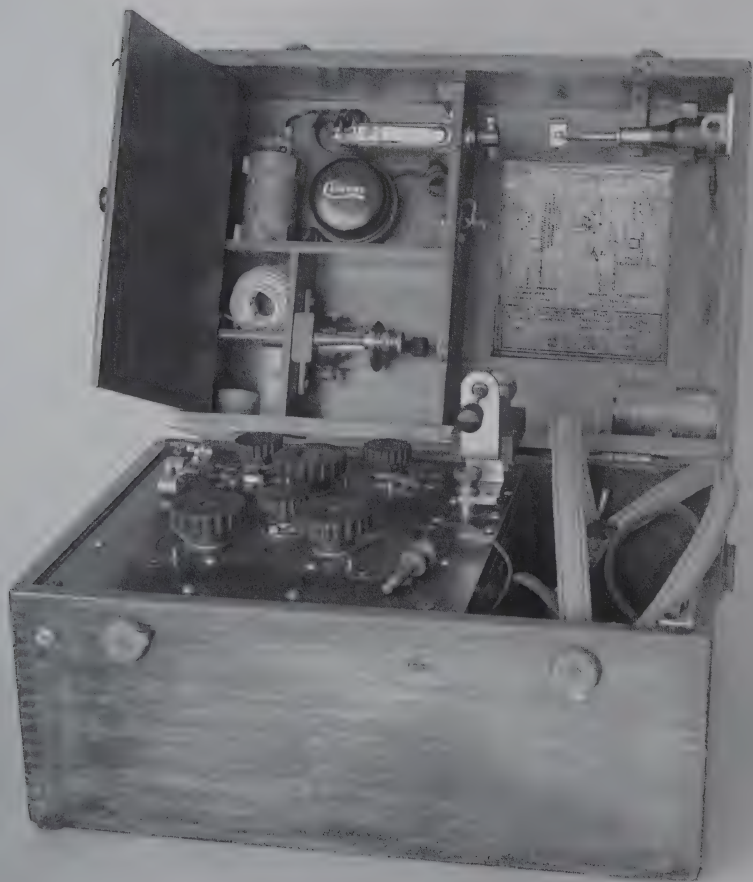


Fig. 16. The BC-14 box for the SCR-54 was virtually indistinguishable from that of the AR-4.

for the production numbers of the eight complete sets reported in this reference.

The problem with this conjecture is that there were significantly more than 7,752 SCR-54A receivers alone produced—perhaps as many as 22,500 (see section Tips for Collecting below), and a significant number of these were produced before the end of the war. Consequently, the 7,752 figure could not possibly account for both the SCR-54 and SCR-54A sets. Actually, the 7,752 SCR-54 sets cited in the report is not unreasonable, given the fact that three different contracts were awarded to three different manufacturers, and there is reason to believe that the Signal Corps purchased at least some of the SCR-54A sets in increments of 2,500. So, if the SCR-54 sets were also purchased in the same increments, the three contracts would neatly account for 7,500 sets.

If, indeed, a total of 7,752 SCR-54 sets were manufactured, then one might ask where all those sets are today. If 7,752 SCR-54 sets and 17,500 to 22,500 SCR-54A sets had been manufactured—for a ratio of 1-to-3—and the same fraction of these sets had found their way to the public, then one might expect that one SCR-54/BC-14 box would appear in flea markets and Internet auctions today for every three SCR-54A/BC-14A boxes. However, the observed ratio has been and continues to be significantly less than that.

One logical explanation for the discrepancy is that a large number of the SCR-54 sets—most of which were manufactured in late 1917 and early 1918—were sent to war in Europe, from whence few may have returned. It is notable that no SCR-54 sets were reported to be in the Signal Corps depots in the U.S. as of June 30, 1919 ver-

sus 5,537 SCR-54A sets.²⁵ Since a large number of SCR-54A sets were manufactured in the months just before and just after the armistice, it is logical to assume that a large fraction of the SCR-54A sets manufactured were never shipped to Europe.

The majority of SCR-54 sets that did survive were probably those that remained in the U.S. for training. This hypothesis is consistent with the serial number evidence available, albeit minimal. Of the three SCR-54 sets with serial numbers I have seen, all have numbers at or below 232. It is extremely unlikely that three serial numbers drawn essentially at random out of a population of 5,000 sets (only two of the three manufacturers assigned serial numbers) would all have such low numbers—so either significantly less than 5,000–7,500 were made, or more likely, they were drawn from a population of the earliest sets that were delivered to training sites in the U.S. Clarence Tuska, a lieutenant in the Army during World War One assigned to develop a radio training school at Ellington Field in Huston, TX, recalled there were no radios there when he arrived on Dec. 26, 1917, but early in 1918 his first shipment of SCR-54 receivers, SCR-55 detectors, and AR-3 antennas arrived.²⁶ Clearly, these would have been the first ones off the production line, and therefore would have had low serial numbers.

SCR-54A Crystal Receiver (BC-14A): Many of the mechanical changes suggested by the AEF users of the SCR-54 were incorporated in the SCR-54A, which was approved for production in June of 1918 by Capt. H. W. Webb, who represented the Research and Inspection Division of the Signal Corps. At least seven different con-

tracts were awarded to four different contractors for the production of the SCR-54A—the first on June 21, 1918 to the General Radio Co. and the last on October 23, 1918 to Liberty Electric. Two other contractors have been positively identified including De Forest and the Marconi Wireless Telegraph Co. of America.

It is certainly possible that there were one or more manufacturers that have not yet been positively identified. Rumors of the existence of sets made by the Wireless Specialty Apparatus Co. have cir-

culated among collectors but they could not be confirmed. Indeed, this author has examined one, but it was actually a set made by one of the four manufacturers already mentioned with a bogus nameplate attached to the lid.

Differences between the BC-14 and BC-14A were both electrical and mechanical in nature. Perhaps the most obvious difference was the buzzer which was moved from the box lid of the BC-14 to the panel of the BC-14A, a change which is evident on the De Forest BC-14A shown in Fig. 17. General

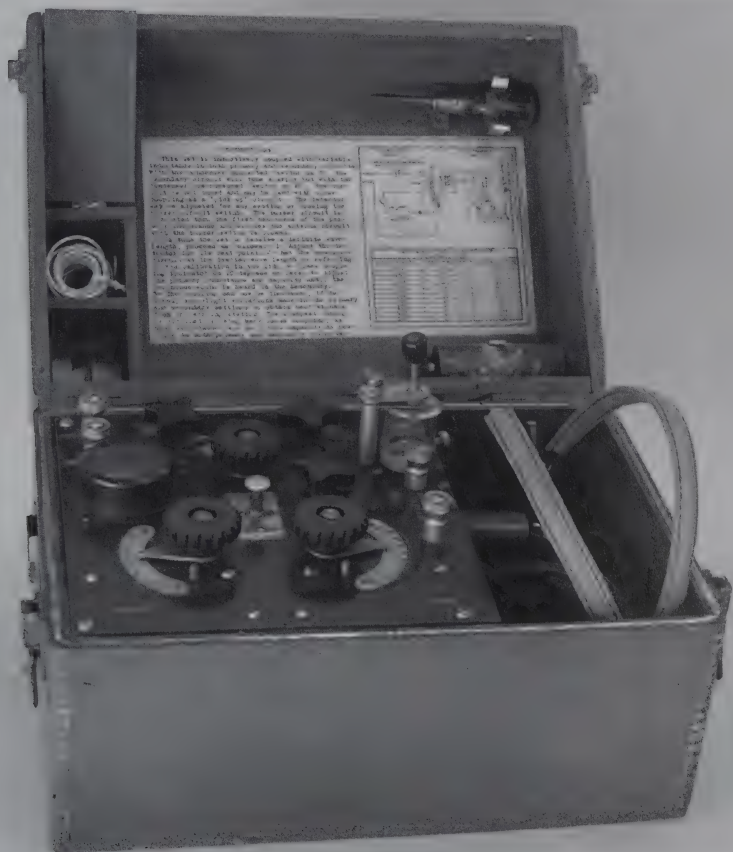


Fig. 17. The most apparent changes made to the BC-14A were the buzzer relocated from the box lid to the panel, the detector permanently mounted to the panel, and a third binding post added to the panel for an emergency headphone connection.

Radio was the only BC-14A manufacturer to reposition the buzzer to the underside of the panel. Except for the buzzer and buzzer switch, the undersides of all BC-14A panels were very similar to the De Forest panel pictured in Fig. 18—and also similar to the underside of the A-1 panel (see Fig. 5).

The buzzers of all BC-14A receivers were wired in series with a battery, a buzzer switch and the primary coil winding of the BC-14A, as indicated in the schematic shown in Fig. 19. There were other minor changes to the circuit, most notably a reversal of the antenna and ground connections in the primary antenna circuit, and a change in the connection of a detector lead from the center of the secondary tap switch to the top of the coil.

Another obvious difference was the panel-mounted crystal detector which replaced the detachable detector used on all previous versions. The two binding posts

used to the mount the detachable detectors were retained to provide connections for an external vacuum-tube detector—as indicated by the label “detector connection” etched into the panel. A third binding post was then added below the two straddling the fixed detector, and this post in conjunction with the adjacent binding post was used as an emergency telephone connection—as indicated by the label “emergency telephone connection.”

A third but less obvious difference was the calibration performed on each set at the factory, which was documented in a chart appearing in instruction sheet affixed to the lid of each box. Handwritten condenser settings entered into right column, when used with the inductance tap positions listed in the middle column, could be used to tune the radio to wavelengths listed in the left column. This option was very convenient when

timelines were short and wavelengths of artillery spotting aircraft were known a priori.

There were a number of other cosmetic differences between the BC-14 and BC-14A, as well as among the various BC-14A sets made by different manufacturers. These cosmetic differences in knob style, buzzer style and location, instruction sheet format, panel color and such will be explored more fully in *Tips for Collecting*.

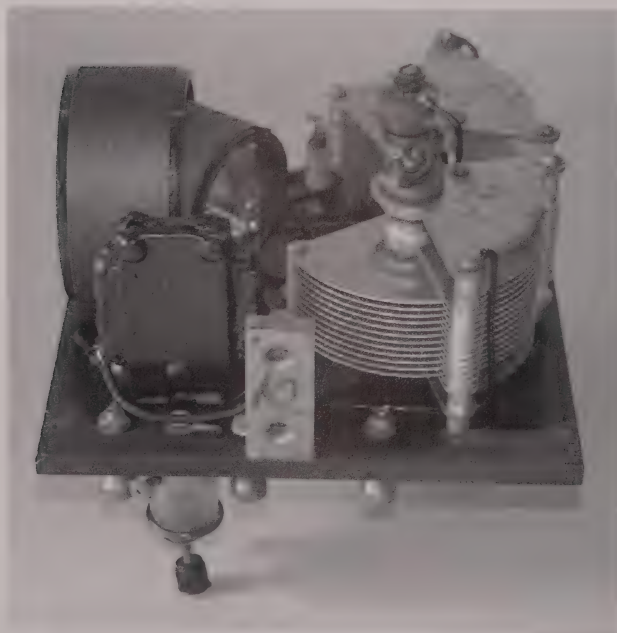


Fig. 18. The interior of this De Forest BC-14A is almost identical to that of the A-1 receiver.

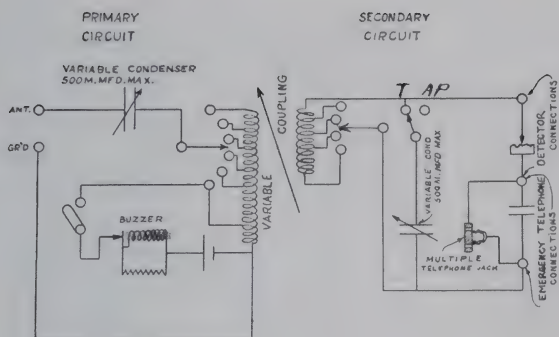


Fig. 19. The circuit of the BC-14A was essentially the same as that of the A-1, differing by a rearrangement of the primary antenna circuit to accommodate the buzzer and a minor change in the detector lead connection.

Evolution of the SCR-55 and DT3/A Vacuum Tube Detectors. Unlike the SCR-54A which evolved from the French A-1 receiver, the SCR-55 and DT-3/A vacuum-tube detectors were of American design. While the French had developed a three-tube set designated Model No. 3-Ter (used in conjunction with the A-1 as either a three stage amplifier or a single-stage regenerative detector with two stages of audio amplification), the Signal Corps had initially determined that a single-stage vacuum tube detector in conjunction with the SCR-54 would provide the necessary sensitivity and selectivity to satisfy the requirements for artillery observation applications.

Like the SCR-54A receiver, the design of the companion vacuum-tube detector underwent several iterations in 1917 beginning with the AR-5, most likely designed by Western Electric. The design was modified at least once before it went into production in the fall of 1917 as the SCR-55. In late 1917, the designation was changed once again to DT-3, denoting the equipment was to be used as an adjunct to another set (i.e., the SCR-54) rather than as a stand-alone set.

In the first half of 1918, the designation was changed once again—this time to DT-3A.

The AR-5 Vacuum Tube Detector: A detector box designated AR-5 was designed around the Western Electric “J” tube (i.e., VT-1) as described in a report entitled “*Report on the Tests of American Vacuum Tube Detector AR-5*” dated January 14, 1918.²⁷ No image of

the AR-5 detector box could be found, but it is evident from the schematic diagram appearing in this report that it was a very basic detector with a classic grid-leak circuit to for biasing the grid and a rheostat to control the filament voltage (see Fig. 20). However basic this set was, the test results summarized in the report indicated that the AR-5 vacuum tube detector increased the energy delivered to the earphones by a factor of twenty-five and increased the selectivity by a factor of two as compared to the crystal detector.

The vacuum-tube detector was designed to be connected to the two binding posts holding the crystal detector after its removal from

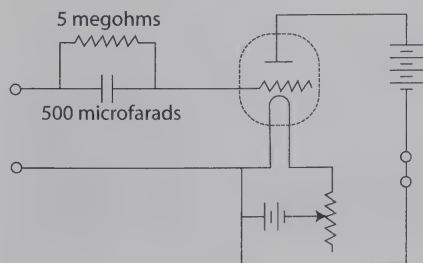


Fig. 20. This schematic for the AR-5 vacuum-tube detector with a classic grid-leak bias circuit was copied from a hand-drawn diagram appearing in a Signal Corps report dated Jan. 14, 1918. (Mike Katzdorn collection)

the AR-4 panel. In order for the grid-leak bias scheme to work with either the AR-4 or SCR-54, it was necessary to short out the blocking condenser placed across the headphone jacks of the AR-4 and SCR-54 receiver boxes to provide the grid resistor a dc return path to the emitting filament. The blocking condenser was conveniently shorted by inserting a tethered shorting plug into the headphone jack of both the AR-4 and SCR-54 boxes (see Fig. 21).



Fig. 21. A shorting plug such as this one tethered to the BC-14 box was required to complete a dc return path for the classic grid-leak bias scheme used with the AR-5 and SCR-55 vacuum-tube detectors.

SCR-55 Vacuum Tube Detector: The Research Section of the Research and Inspection Division made several recommendations for changes to the design of the AR-4, most notably a “split” grid-leak circuit to allow a dc return path from the grid by connecting one end of the grid-leak resistor directly to the emitting filament in the detector itself—thereby eliminating the need for shorting the blocking condenser in the receiver. A second recommendation was the addition of a fixed-inductance coil shunted by a variable capacitor in the plate circuit to produce

regeneration for added gain. Both recommended changes are shown in the circuit of Fig. 22, which was adapted from one appearing in the research report. However, these recommendations were not incorporated in the first production version of the vacuum-tube detector designated SCR-55—most likely because the first production contract was awarded in the fall of 1917, well before the date of this report (January 14, 1918).

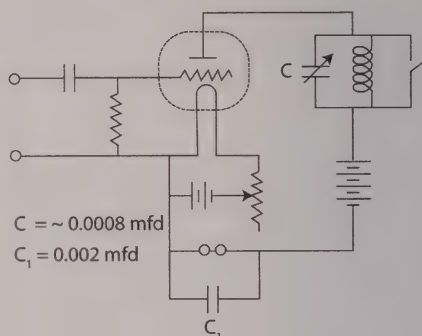


Fig. 22. The Signal Corps report recommended a unique “split” grid-leak circuit to eliminate the shorting plug and a regenerative plate circuit with reactive elements to produce regeneration, both of which are shown in this diagram adapted from the Signal Corps report. (Mike Katzdorn collection)

An example of the first SCR-55 detector unit produced by Western Electric circa October 1917 is shown in Fig. 23. This detector was actually manufactured under the same contract awarded to Western Electric for producing the SCR-54 (see Fig. 24). The circuit of this Western Electric SCR-55 detector shown in Fig. 25 differed from that of the AR-5 in two relatively minor ways: 1) the rheostat in the filament circuit was replaced by a fixed resistance, and 2) two terminal posts with a removable bridging link were incorporated into the plate circuit to allow for



Fig. 23. The SCR-55 shown here was the first vacuum tube detector to be produced in quantity as an adjunct to SCR-54.

a regenerative tickler coil such as the one recommended in the Research Section report. However, it was later determined that the gain which would have been provided by a regenerative tickler coil was not needed, and no tickler coil was ever manufactured or provided for this detector or any of its variants.

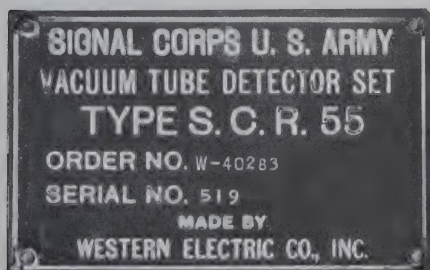


Fig. 24. The first SCR-55 production units were manufactured by Western Electric under Order No. W-40283, the same contract awarded to Western Electric for the companion SCR-54 receiver.

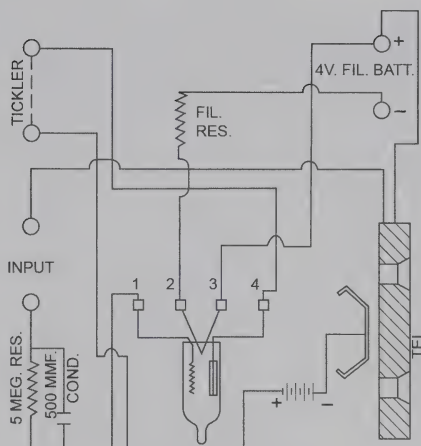


Fig. 25. The SCR-55 circuit did not incorporate the recommendations made by the Research Section regarding the change in the grid-leak bias circuit or the addition of a tickler circuit.

A second contract for the SCR-55 was awarded to De Forest Radio Telephone and Telegraph Co. on March 12, 1918, this according to the nameplate shown in Fig. 26. However, since this contract was awarded well after the Signal Corps changed the designation of the detector to DT-3 and awarded a contract for a DT-3 detector to Connecticut Telephone on Dec. 26, 1917 (see next section), it is curious that the nameplate of this

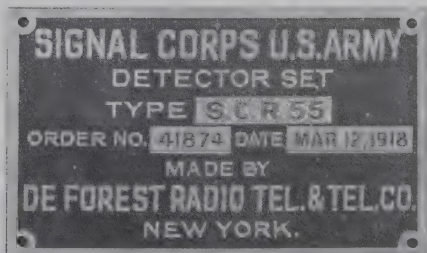


Fig. 26. According to this nameplate, a second contract for the SCR-55 was awarded to De Forest Radio Telephone and Telegraph Co. on March 12, 1918. (courtesy of A. J. Link)

De Forest detector still carried the SCR-55 designation. Since an example of the De Forest detector itself was not located prior to publication of this article, nothing can be said here about the circuit or panel layout.

DT-3 Detector Equipment: Connecticut Telephone and Electric was awarded a contract dated Dec. 26, 1917 to produce additional vacuum-tube detectors (see Fig. 27), but by this time the Signal Corps had changed the designation from SCR-55—the designation for a complete set—to DT-3, an “equipment” designation indicating that it was to be used with other sets. It is not known whether the box for the DT-3 was assigned the same BC-19 designation used for the box that came with the complete SCR-55 set.

Connecticut Telephone produced three variants of the DT-3 under the single contract Order No. 40723 dated Dec. 26, 1917 with two distinctly different grid biasing schemes—neither of which was the same as that used with the SCR-55 manufactured by Western Electric. It is unusual, but not unheard of, that a circuit would be changed in the middle of a production run without a change in designation. When that happened, it was usu-

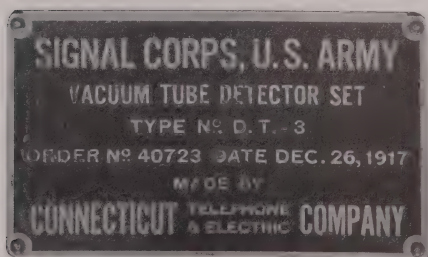


Fig. 27. The Connecticut Telephone and Electric Co. was awarded a contract dated Dec. 26, 1917 to produce additional vacuum-tube detectors, but by this time the Signal Corps had changed the designation to DT-3.



Fig. 28. This DT-3 detector designated Type 1 is believed to be the first of three known versions manufactured under the same contract awarded to Connecticut Telephone. (Mike Katzdorn collection)

ally due to either a problem with functionality or because a design modification made it more economical to produce. In this case, there is no information on why the circuit design change was made, or even which of the two biasing schemes was used first.

The DT-3 detector variant shown in Fig. 28 used the filament battery to bias the grid (see Fig. 29)—the same technique used by De Forest in his first audion patent. Because this technique is considered to be the more primitive of the two biasing techniques, this variant is believed to be the first produced, and will be referred to hereafter as Type 1. The panel had the same physical appearance as the predecessor SCR-55, but why the bias scheme was different from the grid leak-bias circuit used in the SCR-55 is unknown.

It is believed that the DT-3 pictured in Fig. 30 and designated

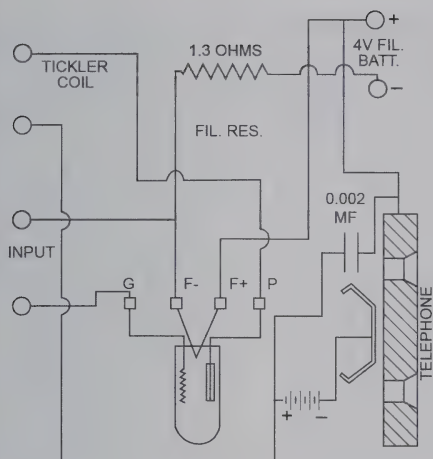


Fig. 29. The Type 1 version of the DT-3 was biased by the filament battery, the technique first used by De Forest in his original audion triode patent. (Mike Katzdorn collection)

here as Type 2 was the next variant manufactured by Connecticut Telephone. The grid bias scheme

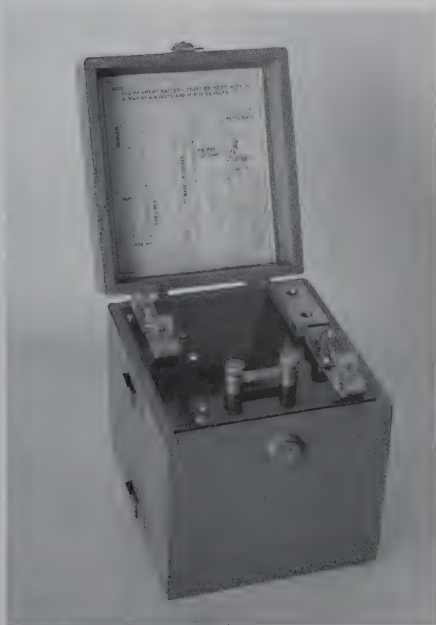


Fig. 30. This DT-3 detector designated Type 2 is believed to be the second of three versions known to be manufactured by Connecticut Telephone.

was the very distinct “split” grid-leak bias circuit recommended in the Research Section report dated Jan. 14, 1918 which eliminated the need for a shorting plug when it was used with the SCR-54 (see Fig. 31). The most obvious physical differences in the Type 2 variant were the two pairs of large Fahnestock clips which replaced the much smaller clips used on Type 1, and repositioning of the binding posts labeled “TICKLER” from the lower left side of the Type 1 panel to the front and center of the Type 2 panel. This repositioning was almost certainly a result of the large size of the new Fahnestock clips.

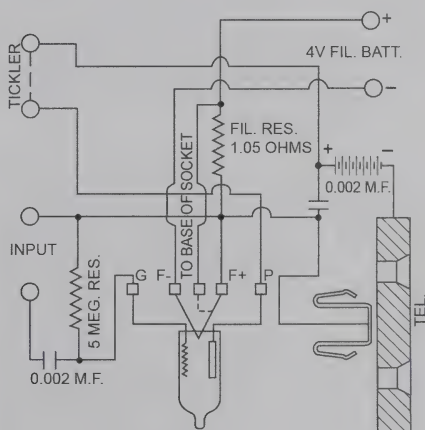


Fig. 31. The Type 2 DT-3 detector was biased with the “split” form of the grid-leak bias circuit recommended by the Research Section of the Signal Corps in early 1918.

The last variant referred to here as Type 3 used the same Type 2 grid-bias circuit, but the oversized Fahnestock clips were replaced by the binding posts which are evident in the photograph of Fig. 32. The binding posts were clearly not a post-production retrofit because the labels engraved in the Type 2 panels next to the posts are in a slightly different position from those engraved on the Type 3



Fig. 32. This DT-3 detector designated Type 3 is believed to be the third of three known versions manufactured by Connecticut Telephone. (Mike Katzdorn collection)

panels. The “tickler” binding posts, which had been repositioned to the front center of the Type 2 variant as a result of the oversized Fahnestock clips, remained in their new position.

DT-3A Detector: The DT-3A detector is described in four government documents—an instruction manual covering the SCR-54/A receiver and the DT-3A detector dated Oct. 24 1918,²⁸ the *Annual Report of the Chief Signal Officer* dated 1919,²⁹ the *Storage Catalog* dated October 1920,³⁰ and the *Radio Operator – Students Manual for All Arms* dated 1924.³¹ According to these documents, the DT-3A detector was designed for use with the SCR-54A, and the box was given the designation BC-19A. However, no other references to this set could be found in the literature of the day, and no examples of this set could be found anywhere—not even after an extensive search through artifacts in the AWA Museum, a query placed in

the January 2010 issue of the *AWA Journal* seeking information, and networking with numerous collectors of World War One hardware. Clearly, this set is very rare, if, in fact, it was actually produced.

Given the fact that few, if any, DT-3A sets exist, and yet so many SCR-54A sets for which it was designed were produced, it is most likely that the DT-3A was not manufactured in quantity—despite its mention in the documents just referenced. Support for this conjecture comes from several sources, not the least of which is *Annual Report of the Chief Signal Officer for 1919* which, when referring to the vacuum-tube detector as a companion to the crystal receiver, clearly stated: “Favorable reports were received from American Expeditionary Sources in January, 1918, but it was concluded that the crystal detector was sufficiently sensitive. The set was later modified by the Western electric Co. and complete drawings made up by the radio laboratories.”³²

If the crystal set had been determined to be sufficiently sensitive without a vacuum-tube detector in early 1918, then there would have been no reason to issue a follow-on contract to the DT-3 detector, which had just been awarded on Dec. 26, 1917—particularly with the attendant complication of producing, storing, and distributing a large number of additional batteries. Indeed, there was no reference to a production of the DT-3A in the above quote—only a statement that complete drawings were made up by the radio laboratories.

The cynic might point out that there is a photograph and schematic diagram of the DT-3A detector in the instruction manual referenced above—which constitutes proof that it was manufactured. However, there is much amiss in

this manual—not the least of which a schematic diagram labeled DT-3A (reproduced here as Fig. 33), which is distinctly different from the schematic diagram clearly visible in the lid of the vacuum tube detector appearing in the photograph, also labeled DT-3A (reproduced here as Fig. 34). Based on this inconsistency, either the image of the set, the circuit diagram or both are indisputably incorrect. There are other obvious errors in the instruction manual regarding the use of the DT-3A in conjunction with the SRC-54, which would make it appear that the authors and editors did not have an example of a DT-3A when preparing the manual. Since the image of the vacuum detector in the manual is indistinguishable from the SCR-55, it may well be that the set pictured in this manual was, in fact, an SCR-55 detector.

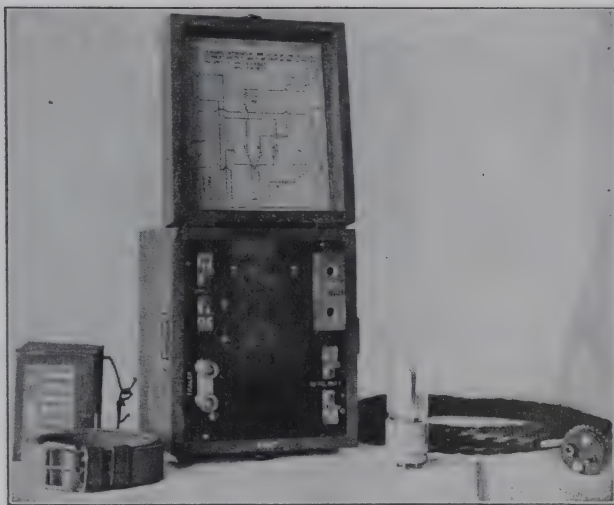


Fig. 34. This schematic diagram of the DT-3A detector appearing as Fig. 6 in Radio Pamphlet No. 3 is inconsistent with the schematic appearing in the lid of set labeled DT-3A appearing as Fig. 7 of the pamphlet.

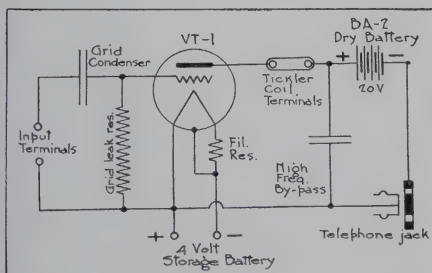


Fig. 33. This schematic diagram, which is labeled DT-3A in Fig. 6 of the instruction pamphlet, is inconsistent with the diagram in the lid of the vacuum-tube detector, which is labeled DT-3A in Fig. 7 of the pamphlet.

An image of set labeled DT-3A along with a schematic diagram appeared in a later *Radio Operator* manual dated 1924.³³ This set also appears to be a SCR-55, just like the earlier manual, but the biasing scheme here is the original classic grid-leak method first used with the SCR-55—a circuit which would not work using the two connectors on the BC-14A labeled “detector connection” without a shorting plug. However, the vacuum tube detector connection to the BC-14A specified in the *Radio Operator* manual is made between the top and bottom connectors—not the two labeled “detector connection.” Ironically, the lower binding post added for an emergency telephone connection also happens to bypass the blocking condenser and provides the necessary return path for any vacuum-tube detector biasing scheme. Thus, all of the companion detectors made by the Signal Corps—including the SCR-55—could be used with the BC-14A without a shorting plug.

This realization, which obviously came after the manufacture of the BC-14A with the misguided “detector connection” label between the top two binding posts, may have factored into a decision not to manufacture the DT-3A. There is little else that can be said about the DT-3A detector without examining an actual example.

TIPS FOR COLLECTING THE BC-14A

The BC-14A is unique among all radio equipment developed by the Signal Corps during World War One in several respects. First, more of these boxes were manufactured than any other model, and a large number of them have survived to this day. There are no data on the total number of SCR-54A (BC-14A) sets manufactured—only a reference in a report by the Chief Signal Officer of the Army that approximately 5,300 of these sets were in Signal Corps depots on June 30, 1920, the end of the fiscal year.³⁴ Of course, this number does not represent the sets that were in the field. It will become clear later in this section that many more than 5,300 of these sets were manufactured, and in fact, a plausible case will be made that somewhere between 17,500 and 22,500 were made.

Sometime between June of 1920 and March of 1923, the SCR-54A sets were declared to be obsolete and were sold as surplus. Advertising notices for the sale of surplus BC-14A boxes at a price of \$7.50 appeared in the fall of 1922 in journals aimed at military personnel.³⁵ These sets were advertised to operate from 200 to 600 meters (500 kHz to 1.5 MHz), which neatly covered the broadcast band, and as a result, they were quite popular among broadcast radio listeners.

The following statement appeared in *The Coast Artillery Journal* dated March 1923: “The sale of obsolete S.C.R. 54A receiving sets has opened a path for those in the service to purchase a receiving set at relatively small cost, \$7.50.”³⁶ Not mentioned in this article was the fact that the earphones were offered separately at \$3.50—but still, the complete receiver totaled only \$11. Indeed, at this price the BC-14A receiver was much less expensive than the less sophisticated Radiola I crystal set with earphones, for example, which appeared on the market in August, 1922 for \$25.

This article in *The Coast Artillery Journal* also described how the SCR-54A could be modified to greatly increase its range—characterized as 25 miles with a crystal detector—by adding vacuum tubes. Two methods of modifying these sets “to meet the requirements of musical reception” were presented, a one-tube regenerative detector using a variometer in the plate circuit at an estimated cost of \$9.80, and a two-tube set with a detector and one stage of audio amplification at an estimated cost of \$12.50.

A circuit almost identical to the one-tube set presented in *The Coast Artillery Journal* also appeared in the August, 1924 issue of *Radio News* in response to a question from a reader on how to modify the BC-14A crystal receiving set to make a single-tube set.³⁷ A schematic diagram of the circuit published in *Radio News* was glued into the lid of one of the SCR-54A receivers I purchased. Clearly, a very large number of the surplus BC-14A sets made their way into the hands of radio enthusiasts.

Another distinguishing feature of the BC-14A is its extreme popularity among today’s collectors. It appears on the market more

often than any other World War One Signal Corps radio, and it fetches premium prices—often between \$1000-\$2000 depending on manufacturer and condition, and occasionally more than \$4000. Furthermore, there appear to be more different versions of this set made in quantity by more manufacturers than any other World War One radio, a feature which enhances its attractiveness to collectors. I have catalogued seven distinguishable variations among the seven production runs by four different manufacturers, and there may be others.

While a large number of variants enhance the collectability of a particular set, it also presents a greater opportunity for mischief by collectors who can trade nameplates and/or panels among sets to either “complete” a set or to make a more common set such as the Liberty Electric appear to be a more desirable set such as a De Forest. Parts have been switched on no less than three sets I purchased on Internet auctions, and so it must be a very common occurrence. It is difficult for the uninitiated to determine whether a particular BC-14A has been altered, but with the pointers contained in the remainder of this article, even the novice will be able to tell at glance whether the set has been substantively altered by interchanging or substituting parts.

There are four major points of agreement on the BC-14A that need to be checked to see if the set is original: the nameplate, the panel, the instruction sheet, and the box itself. The key features to check the points of agreement appear in Table 2 as follows: Order No. and date on the nameplate, the panel color (black or brown), the location of the buzzer (above or below the panel), the type of knob (knurled,

fluted, or 4-arm), the color of the instruction sheet in the box lid (white or blue), and the number of paragraphs appearing on the instruction sheet (two or five). Although not listed in the table, the details of the binding posts are also useful for distinguishing between De Forest and Liberty Electric sets when the color of the panels cannot be distinguished. Some of the extremely subtle differences in box construction among the four manufacturers are addressed in the text.

General Radio BC-14A Receivers: The General Radio Company was awarded the first two contracts for the production of the SCR-54A, one dated June 21, 1918 and the other dated July 8, 1918—this according to the information on the two respective nameplates (see Fig 35.) According to data appearing in the August 19, 1918 issue of *Aerial Age*,³⁸ General Radio received a contract for 2,500 receiving sets, which presumably refers to one of these two contracts. No information on the number of sets made on the second contract has been found, but if the number

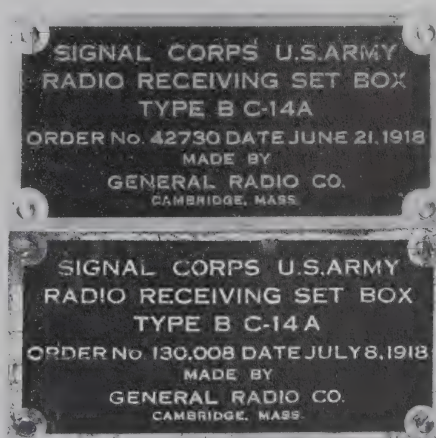


Fig. 35. General Radio nameplates attached to its BC-14A boxes provide evidence of contract order numbers and dates of award.

Table 2. Key features used to distinguish between and among BC-14A receiver boxes

Manufacturer	Nameplate		Buzzer Location	Panel Color	Knobs (size)	Instruction Sheets & Boxes
	Order #	Date				
General Radio	42730	06/21/18	Under panel	Black	Knurled (all)	Blue instruction sheets; all other manufacturers used white sheets
General Radio	130008	07/08/18			Fluted (large)	
De Forest	130009	07/11/18	Top of panel	Brown	4-Arm (small)	Only instruction sheets with two paragraphs
De Forest	130339	09/12/18			Fluted (all)	
Liberty Electric	130019	07/16/18	Top of panel	Black	4-Arm (small)	Only unpainted box interior
Liberty Electric	130453	10/23/18			Fluted (large)	Painted box interior
Marconi	130018	1918	Top of panel	Black	Fluted (all)	Similar to Liberty Electric sheets

manufactured on both contracts were equal, General Radio would have made a total of 5,000 sets.

The General Radio panels can be easily distinguished from those made by all other manufacturers by the absence of the buzzer on the top of the panel. The buzzer was located on the underside of the panel on all General Radio—unlike all other sets where the buzzer was permanently mounted to the top left side of the panel about half way between the top and bottom. The blue instruction sheets firmly affixed to the lids of General Radio are also easily distinguished from the white instruction sheets used by all other manufacturers. Further, the GRC boxes are also unique in that the two left panel brackets are held by screws protruding through the left side of the box wall, whereas all other manufacturers mounted the brackets with all screws protruded though either the front or rear wall of the box but never the side.

The receivers made under the two General Radio contracts have slightly different panels as shown in Fig. 36 and Fig. 37. The two can easily be distinguished from each other by the type of knobs on the panel. All knobs used on the first contract (#42730) are knurled with a relatively smooth appearance, whereas the large knobs used on the second contract (#130008) are distinctly fluted.

De Forest BC-14A Receivers: De Forest was also awarded two contracts for the BC-14A, Order No. 130009 dated July 11, 1918 and Order No. 130339 dated Sept. 12, 1918, data taken from the nameplates shown in Fig. 38. The panels on the De Forest boxes used in the two different production runs can be distinguished from each other most easily by the style of the knobs. While the large knobs on both sets were fluted, the small knobs on the sets from the first contract have a star shape with four arms whereas the small



Fig. 36. The General Radio BC-14A panel from the first contract #42730 is easily identified by the absence of a visible buzzer and the knurled knobs without fluting.

knobs from the second contract are fluted (see Fig. 39 and Fig. 40). No serial numbers appear on the nameplates, and no data on the number of sets manufactured by De Forest could be found.

The panels for the sets made on both De Forest contracts can be distinguished from panels made by all other manufacturers by the

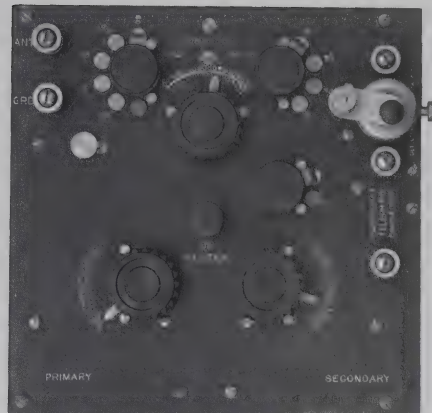


Fig. 37. The General Radio BC-14A panel from the second contract #130008 is easily distinguished from the first contract by presence of fluting on the large knobs.

presence of a decidedly brown cast to the Bakelite-type panel itself, whereas those made by all other manufacturers were black. Unfortunately, the color of the panels cannot always be discerned, particularly when the photos appear in black and white as they do here. It is even more unfortunate that the panels of the Liberty Electric sets are almost identical to the De Forest panels, and so the Liberty Electric BC-14A sets are often sold as De Forest sets by simply switching the nameplates. However, there is a relatively easy way to distinguish De Forest panels from Liberty Electric panels. The De Forest sets have binding posts with a screwdriver slots in the top of the binding post whereas the binding posts on the Liberty Electric sets do not (see Fig. 41).

The boxes from De Forest receivers can also be distinguished from all others by the instruction sheets glued to the interior lid—assuming of course that the instructions have not been replaced. The De Forest instruction sheets are unique in that the wording was formatted using only two para-



Fig. 38. De Forest Company nameplates attached to its BC-14A boxes provide evidence of contract order numbers and dates of award.

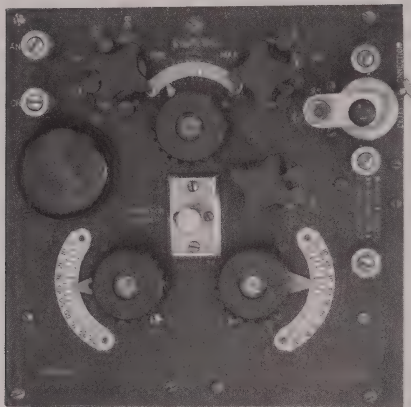


Fig. 39. The De Forest BC-14A panel from the first contract #130009 is easily identified by the brown color of the panel, small knobs with four arms, and the screwdriver slots on the binding posts.

graphs—whereas the instructions used by the other three manufacturers were formatted using five paragraphs. The De Forest box can also be distinguished from all other by way in which the hinge is mounted on the back of the lid of the small compartment located in

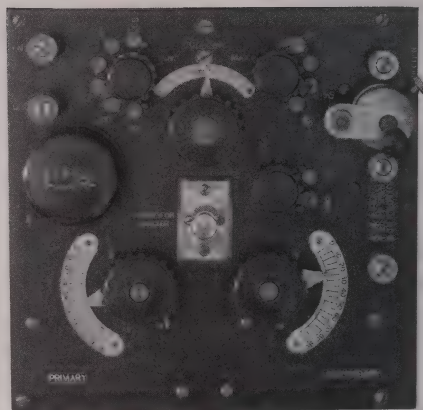


Fig. 40. The De Forest BC-14A panel from the second contract #130339 is easily identified by the brown color of the panel, the fluting on all knobs, and the slots on the binding posts.

the lower left corner of the box lid. Hinges on De Forest sets are the only ones that are flat when the small lid is closed. All other manufacturers mounted the hinges such that the hinge plates form right angles when the small lid is closed.

Liberty Electric BC-14A Receivers: The Liberty Electric Company received two relatively large contracts to manufacture the BC-14A in the second half of 1918, the first with Order No. 130019 dated July 16, 1918 and the second with Order No. 130453 October 23, 1918 as indicated by the nameplates shown in Fig. 42. The serial numbers appearing on the ten Liberty Electric nameplates I have seen range from a low of 301 and a high of 4462, indicating that there were perhaps as many as 5,000 manufactured. However, the highest and lowest observed were both from the second contract bearing the same order number, and therefore it is possible, even probable, that as many as 5,000 were manufactured on the second contract—and perhaps 5,000 on the first contract, as well—for a grand total of between 7,500 and 10,000 sets.

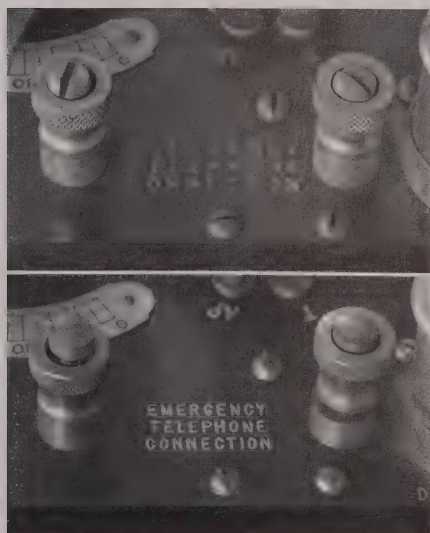


Fig. 41. The De Forest panels have binding posts with slots (top), whereas the binding post on Liberty Electric panels do not (bottom).

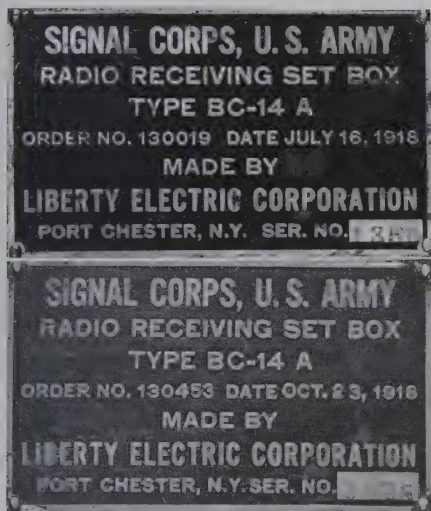


Fig. 42. Liberty Electric nameplates attached to its BC-14A boxes provide evidence of contract order numbers and dates of award.

The case for Liberty Electric making a significantly larger number of sets than any other manufacturer is supported by two independent observations. First, it is generally known among collectors of this set that significantly more Liberty Electric BC-14A have appeared in the collecting

market than sets made by any other manufacturer. Second, the two Liberty Electric contracts for the SCR-54A using the BC-14A box appear on a list of contracts exceeding \$100,000 issued by the Signal Corp between Apr. 6, 1917 and June 1, 1919,³⁹ while contracts for the sets made by the three other manufacturers are strikingly absent from this list. More to the point, the dollar value expended on the two Liberty Electric contracts as of June 1, 1919 was significantly in excess of \$100,000 (\$121,000 and \$151,250 respectively), indicating that either Liberty Electric manufactured significantly more sets than any of the other three contractors, or the Liberty Electric sets were significantly more expensive. It is logical to conclude that Liberty Electric manufactured significantly more SCR-54A sets.

The two different Liberty Electric BC-14A panels shown in Fig. 43 and Fig. 44 are almost identical to each other and to the De Forest panels manufactured under the first contract. As a result, it is easy to mistake the Liberty Electric sets for De Forest sets. However, as

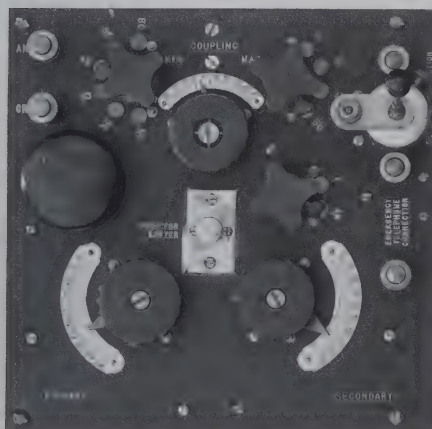


Fig. 43. The first panel type initially used Liberty Electric contract #130019 is easily identified by the label "PUSH FOR BUZZER."

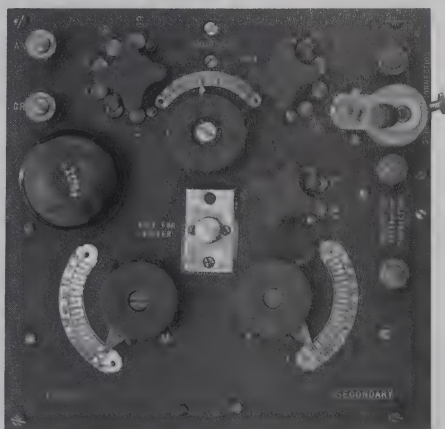


Fig. 44. The second panel type shown here from Liberty Electric contract #130453 can be distinguished from the first panel type by the label "PULL FOR BUZZER."

pointed out previously, the De Forest panels can be distinguished by the brown color of the panels which is unique to De Forest sets, and by the existence of screwdriver slots on the binding post caps of the De Forest sets.

The striking similarity of the Liberty and De Forest sets—in contrast to the many differences between and among sets from the other two manufacturers—leads one to believe that there must have been some degree of cooperation between the two companies in the manufacture of Liberty Electric sets. One common factor between the Liberty Electric and De Forest companies is Harry Shoemaker, who was named Chief Engineer of Liberty Electric about the time it was incorporated on June 27, 1917 for the specific purpose of manufacturing equipment for the war effort. Recall that Harry Shoemaker was also an engineer for the America De Forest Wireless Telegraph Company in the early 1900's, and had a warm relationship with de Forest throughout his lifetime—in later years, de Forest characterized Shoemaker as a “*staunch and loyal associate*.”⁴⁰ As such, he would have been in a good position to make some type of arrangement with the De Forest Company to acquire the necessary components from common sources.

Just as the Liberty Electric panels can easily be distinguished from the De Forest panels by the trained eye, the two variants of the Liberty Electric panels can also be distinguished by the trained eye. The buzzer switches used on early Liberty Electric panels manufactured under the first contract (#130019) operate by pushing the buzzer switch down, and the label engraved in the panel next to the switch reads “PUSH FOR

BUZZER”—which, incidentally, is identical to the operation on all De Forest sets. However, the buzzer switch appearing on later Liberty Electric panels from the first contract—and most, if not all of the panels manufactured on the second contract (#130453) operate by pulling the switch up, as indicated by the panel label which reads “PULL FOR BUZZER.”

The reason for the reversal in function of the buzzer switch in the middle of the first production run has not been documented. It may have been due a shortage of parts, or perhaps a result of an unintended design flaw. For example, field tests with earlier BC-14A receivers might have revealed that the buzzer could be unintentionally activated when the operator closed the box with his manual or other possessions inside, a flaw which would have been easily eliminated by reversing switch functionality.

While the construction of wood boxes used by all manufacturers is virtually identical, the interiors of the boxes made on the first Liberty Electric contract (#130019) are unique in that they are unpainted, revealing an oak grain which is highly visible even in black and white photographs. The white instruction sheets found on the lids of the Liberty Electric sets, which consist of five paragraphs, are different from the De Forest instructions which consist of only two paragraphs. However, the Liberty Electric instruction sheets are virtually identical to those found on the Marconi sets, and therefore cannot be reliably used to distinguish between the two.

Marconi BC-14A Receivers: Marconi was awarded at least one contract for the BC-14A, an example of which is shown in Fig. 45. The existence of an engineering drawing of a BC-14A in the *Ra-*

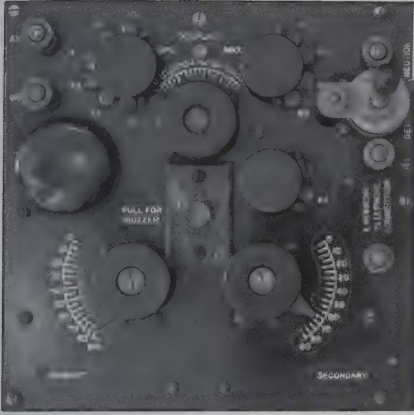


Fig. 45. The Marconi panel used on contract #130018 is the only one with both a nickel finish on all panel hardware and a buzzer mounted on top of the panel.

dioana collection with the Marconi name confirms beyond doubt that Marconi was awarded at least one contract.⁴¹ The scarcity of these sets in the collecting community as compared to all others would indicate that fewer sets were manufactured, leading to a speculation that there may have been only one contract.

The nameplate shown in Fig. 46 bears the Order No. 130018 and the year 1918, but no specific date. Based on the order number which falls between two other contract numbers with known dates (see Table 1), the contract

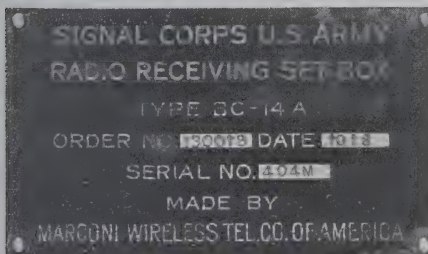


Fig. 46. The Marconi nameplate attached to the box manufactured under the only known Marconi contract provides evidence of the order number and year of manufacture.

must have been awarded between July 11th and July 16th of 1918. Serial numbers were stamped on the nameplates, but not enough Marconi sets were available to make an estimate of the number of sets manufactured.

The Marconi BC-14A can easily be distinguished from all others by the nickel finish on the panel hardware in conjunction with the buzzer mounted on top of the panel. General Radio was the only other manufacturer to use a nickel finish, but their buzzer was mounted underneath the panel. Marconi also used a buzzer switch with a reversed function similar to that used by Liberty Electric, whereby the buzzer was activated by pulling up on the switch. Like the second Liberty Electric panel, the Marconi panel is also engraved with the label "PULL FOR BUZZER." As mentioned previously, the Marconi instructions sheets are virtually identical to those used by Liberty Electric.

Ancillary Equipment: The receiver for the SRC-54 and/or SCR-54A sets came with other components which are often visible in early photographs: P-11 telephones (i.e., headsets) with jacks, Type BA-4 1.5 volt batteries, size "D" batteries, a Stanley TL-2 4-inch screwdriver or equivalent, an ST-5 carrying strap, and a spare coil of wire. Examples of each believed to be original are shown in Fig. 47.

These components are quite rare, but it is possible to find them—or perhaps ones that are very similar. Type BA-4 batteries with a length of 3-1/16 inches were specified for both the SCR-54 and SCR-54A, but the battery contacts in many of these sets have been moved to accommodate "D" batteries which are almost 3/4 of an inch shorter than the BA-4. Batteries of both sizes—identical in



Fig. 47. Ancillary equipment used with the SCR-54 and/or SCR-54A variant include Type P-11 telephones, Type BA-4 and type "D" 1.5 volt batteries, a TL-2 4-inch screwdriver, an ST-5 carrying strap, and a spare coil of wire.

appearance—were found with one set, and both sizes appear to be original Signal Corps issue. The screwdriver was specified to be a 4-inch No. 25 by Stanley or equivalent, but Stanley did make several screwdrivers that are equivalent in length and appearance. The ST-5 strap was made of braided canvas with a width of $1\frac{3}{8}$ inches and a length of 82 inches. The wire for the SCR-54 set was described as 7-strand braided, No. 30 B & S gauge which was rubber covered with white silk. The wire for the SCR-54A was simply described as wire wound in a coil with an outside diameter of $1\frac{1}{2}$ inches.

ACKNOWLEDGEMENTS

I would like to acknowledge a number of fellow collectors and historians for providing documents, images, and other support without which this article would have been quite incomplete. In particular, I would like to thank Mike Katzdorn for both his counsel and for images of rare documents and artifacts from his extensive collection. I would also like to thank A. J. Link, Jack Weatherby, Alan Douglas, Russ Kleinman, Donald Patterson, and Howard Stone for their contributions,

photographs and/or comments. Finally, I would like to thank the AWA Museum, the *AWA Journal*, Bjorn Forsberg, and other fellow collectors for their support in attempting to locate an example of the elusive DT-3A vacuum tube detector. Please contact me at admin@chezwenaas.com, should you have or find one.

ENDNOTES

- 1 U.S. Signal Corps, *Radiotelegraphy*, (Government Printing Office, Washington, 1917).
- 2 B. Crowell and R. Wilson, *The Armies of Industry II. Our Nation's Manufacture of Munitions for a World in Arms 1917-1918*, (Yale University Press, New Haven, 1921) pp. 572-573.
- 3 G. F. Gray and J. W. Reed, "Radio Apparatus for Artillery Fire," *Electrical World*, Vol. 73, No. 9, March 1, 1919, pp. 408-412.
- 4 G.W. Mixer and H. H. Emmons, *United States Army Aircraft Production Facts*, (Government Printing Office, Washington, January, 1919) p. 90.
- 5 Ibid.
- 6 L. Babcock, "First World War Aircraft Radio," *AWA Review*, Vol. 20, 2007, pp. 75-96.
- 7 See for example: *Airplane Radio Telegraph Transmitting Set (SCR-73)*, Radio Pamphlet No. 13, (Signal Corps, U.S. Army, 1918); G. F. Gray and J. W. Reed, *Electrical World*, March 1, 1919, pp. 408-412; D. Patterson, "SCR-73 WWI Airplane Transmitter," *Radio Age*, Vol. 14, No. 1, Jan. 1988, pp. 1-3.
- 8 See for example: *Airplane Radio Telegraph Transmitting Sets (SCR-65, 65-A)*, Radio Pamphlet No. 5, (Signal Corps, U.S. Army, 1918); B. Gould, "Airplane Radio Telegraph Transmitting Set Type SCR-65," *Old Timers Bulletin*, Vol. 13, No. 11, Nov. 1987, p. 11; "Air Corps Communications: World War I," *Old Timers Bulletin*, Vol. 9, No. 1, June 1968, p. 11; C.

- D. Tuska, "A Radio Amateur in World War I," *AWA Review*, Vol. 1, 1986, pp. 51-55.
- 9 N. H. Slaughter, et. al., "Radio-Telephone Development in the Army," *Electrical World*, Vol. 74, No. 7, Aug. 16, 1919, pp. 340-343.
- 10 M. L. Marshall, *The story of the U.S. Army Signal Corps*, (Franklin Watts, Inc. New York, 1965) pp. 161-163.
- 11 *Report of the Chief Signal Officer to the Secretary of War - 1919*, (Government Printing Office, Washington, 1919) p. 314.
- 12 M. Maurer, ed., *The U.S. Air Service in World War I, Vol. 1 - Vol. 4*, (U.S. Government Printing Office, Washington, 1978).
- 13 H. Lauer and H. L. Brown, *Radio Engineering Principles*, (McGraw-Hill Book Co., Inc. New York, 1920) p. 285.
- 14 M. Maurer, ed., *The U.S. Air Service in World War I, Vol. III*, (U.S. Government Printing Office, Washington, 1978) p. 35.
- 15 R. Crack, *Until a Dead Horse Kicks You*, (Kangaroo Press Pty, Ltd., Australia, 2000) pp. 93-94.
- 16 *Report of the Chief Signal Officer to the Secretary of War - 1919*, p. 306.
- 17 "Wireless in the A. E. F.," *The Wireless Age*, Vol. 7, No. 1, Oct. 1919, p. 14.
- 18 Brig. Gen. George O. Squier was promoted to Major General shortly thereafter on Oct. 6, 1917.
- 19 *Report of the Chief Signal Officer to the Secretary of War - 1919*, p. 306.
- 20 *War Expenditures, Hearings before the Select Committee on Expenditures in the War Department, House of Representatives, Sixty-Sixth Congress, First Session on War Expenditures, Serial One - Part 9, War Contracts over \$100,000*, (Government Printing Office, Washington, 1919) pp. 1619-1627.
- 21 Signal Corps, *Storage Catalog*, (Government Printing Office, Washington, Oct. 1920) p. 8.
- 22 *Wireless Age*, Vol. 6, No. 4, January 1919, front cover.
- 23 *Storage Catalog*, pp. 9, 506.
- 24 G.W. Mixer and H. H. Emmons, *United States Army Aircraft Production Facts*, p. 92.
- 25 *Report of the Chief Signal Officer to the Secretary of War - 1920*, p. 51.
- 26 C. D. Tuska, *AWA Review*, 1986, pp. 51-55.
- 27 Division of Research and Inspection, "Report on the Tests of American Vacuum Tube Detector AR-5," January 14, 1918. See website of Mike Katzdorn (<http://users.erols.com/oldradio/eha9.htm>).
- 28 *Radio Receiving Sets Type SCR-54 and Type SCR54-A and Detector Equipment Type DT-3-A*, Radio Pamphlet No. 3, (Signal Corps, U.S. Army, Washington) Oct. 24, 1918.
- 29 *Annual Report of the Chief Signal Officer, 1919*.
- 30 *Storage Catalog*, 1920.
- 31 *Radio Operator~ Student Manual for Small Arms, Part I. Radio Sets*, Pamphlet No. 26 (Government Printing Office, Washington, 1924) pp. 94-99.
- 32 *Report of the Chief Signal Officer to the Secretary of War - 1919*, p. 250.
- 33 *Radio Operator*, pp. 94-99.
- 34 *Report of the Chief Signal Officer to the Secretary of War - 1920*, p. 51.
- 35 An original advance draft of an advertising notice which was to appear in the *Army and Navy Journal* and the *Army and Navy Register* in the fall of 1922 was found with a Liberty Electric BC-14A purchased by the author.
- 36 H. R. Pierce, "Remodeling an S.C.R. 54A Receiving Set," *The Coast Artillery Journal*, Vol. 58, No. 3, March 1923, pp. 257-259.
- 37 *Radio News*, Vol. 6, No. 2, August, 1924, p. 202.
- 38 "The Aircraft Trade Review," *Aerial Age*, Vol. 7, No. 23, Aug. 19, 1918, p. 1123.
- 39 *War Expenditures, Hearings before the Select Committee on Expenditures in the War Department*, pp. 1620-1621.

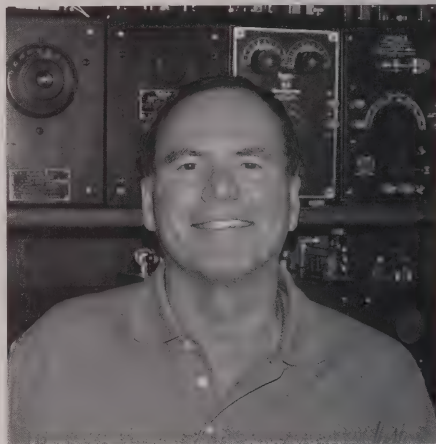
- 40 L. de Forest, *Father of Radio ~ The Autobiography of Lee de Forrest*, (Wilcox and Follett Co., Chicago, 1950) p. 463.
- 41 G. H. Clark, *Radioana*, Archives Center of the National Museum of American History, Smithsonian Institution, Washington, D.C.

ABOUT THE AUTHOR

Eric P. Wenaas has had a lifelong passion for antique radios beginning with his first Radiola and crystal set given to him as a young man growing up in Chicago by family friends. He experimented with radio devices and repaired radios and televisions as a hobby while in high school, and went on to study electrical engineering at Purdue University, graduating with B.S. and M.S. degrees in Electrical Engineering. He then went to the State University of New York at Buffalo where he earned a Ph.D. degree in Interdisciplinary Studies in the School of Engineering. After graduating, he moved to Southern California where he first worked at Gulf General Atomic for several years, and then moved to Jaycor, a defense company in Southern California, where he spent most of his career, first as an engineer and later as the President and Chief Executive Officer.

Upon his retirement in 2002, he set out to research the early days of wireless and document interesting historical vignettes based on original documents of the era. He has written articles for the *AWA Review* and the *Antique Radio Classified*, and has recently published a critically acclaimed book, *Radiola: The Golden Age of RCA - 1919-1929*, covering the early history of RCA—including the formative years of the Marconi

Telegraph Company of America. For this work, he received the AWA Houck Award for Documentation in 2007. He is a member of the IEEE and the Antique Wireless Association, and is a past member of the American Physical Society. Dr. Wenaas resides in Southern California and continues to enjoy collecting and displaying radios, and researching the early days of wireless.



Eric Wenaas

Early Submarine Cable Instruments and Apparatus

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ABSTRACT

The rapid development of the electrical industry in Britain in the second half of the 19th century was closely tied to the introduction of submarine communications cables in 1850. Commercial and government interests quickly recognized the potential gains to be made from having virtually instantaneous communication with distant lands, and a vast investment was made in manufacturing and laying cables. This stimulated the production of pure copper, the felling of hundreds of thousands of trees in Malaysia to provide gutta percha insulation, the drawing of tens of thousands of miles of iron wire to armor the cables, the adaptation of land line instruments for cable use, and the invention of many new instruments and techniques for working the cables. This article examines how the technical requirements of the cable industry led to the development of some of the instruments and apparatus peculiar to ocean telegraphy.

The first practical electric telegraph systems went into service in England in 1839 and in the United States in 1844. Only a few years later, by the late 1840s, enterprising promoters in Britain were proposing undersea cables across the English Channel to France, and after an initial failure in 1850, the first working cable was operational on that route in 1851. And just three years after that, in 1854, in a bold leap of optimism Cyrus Field decided that the Atlantic could be bridged by a 2000-mile cable from Ireland to Newfoundland, about twenty times longer than any yet laid. (Field, 1866)

The short cables then in service could be worked by equipment similar to that used on landlines, with sensitive galvanometers as the receiving instruments. But long cables presented problems several orders of magnitude more difficult to solve, and this eventually led to a number of major advances in instruments for testing and working them. The first difficulty was that the great length of the conductor, together with the low-purity copper available in the 1850s, meant that the signal was heavily attenuated and could barely cause a standard galvanometer needle to twitch, much less show an intelligible signal. And secondly, the very high capacitance of long underwater lines resulted in a time lag and smearing of the signal (known as “retardation”), as the cable slowly charged and discharged with each dot or dash, to the point where individual code elements could not be distinguished at the receiving end. (Bright, 1898).

It should be understood that the electrical engineers of the early 1850s were laboring under considerable difficulties. Even their profession had not yet been defined; many of the cable pioneers were members of the Institution of Civil Engineers in London, and called themselves “electricians”. They had no standard units to work with, and little understanding of the theory of propagation of signals in long

cables, much of their progress being made by experimentation. The now-familiar units of electrical measurement were first proposed by a committee set up in 1861 by the British Association for the Advancement of Science, which in their report of 1863 recommended a set of “absolute practical” electrical units – the volt, ampere, ohm, joule, watt, and coulomb – and defined their magnitudes. These standards were eventually generally adopted. (Elmquist *et al*, 2001)

The solution to the retardation problem will be described later, but the initial concern of the Atlantic cable electricians in the 1850s was to get a readable signal, and there were two ways they could have done this. One was to increase the voltage of the transmitted signal; the other was to improve the sensitivity of the receiving instruments. One of these approaches was taken by Wildman Whitehouse; the other by William Thomson, two men whose working methods could not have been more different.

Thomson came from a rigorous scientific background, technically inclined from an early age and educated at Cambridge University, where he graduated with high honours in 1845, then took up a professorship at Glasgow University. His attention was brought to the problem of signals in long cables in 1854, and he then performed a theoretical analysis of the electrical performance of undersea cables in which he determined that the strength of the signal followed an inverse square law. He made some suggestions for the optimum design of long cables in a paper published by the Royal Society in 1855. (Thomson, 1855).

Edward Orange Wildman Whitehouse was a surgeon by profession, and in common with many educated men of the period he had

an interest in “natural philosophy” – what would now be called physical science. Over his lifetime he experimented in fields as diverse as the recording of musical performances by a mechanical device (his “electric harmoniograph”); meteorology; astronomy; forensic anthropology; and, of course, telegraphy. (Atlantic Cable Website, Whitehouse).

In the early 1850s Whitehouse abandoned his medical practice and started experimenting on signal transmission through electrical wires. He took out several patents in the field, the first in 1853. Based on measurements he made in 1855 of the velocity of signals through lengths made available to him before they were laid of the Mediterranean and Newfoundland submarine cables, Whitehouse publicly disagreed with Thomson’s conclusions. The Mediterranean cable was 150 miles long and had six conductors, which Whitehouse connected in series, and to this he added 75 miles of the Newfoundland cable with three conductors again in series, for a total length of 1,125 miles. From his tests, for which he had devised an ingenious method of measuring the speed of transmission, Whitehouse presented results which he said backed his claims, although Thomson rebutted this. (Whitehouse, 1855; Thomson, 1856; see Fig. 1)

Although he devised a number of elaborate and detailed experiments, Whitehouse’s conclusions were largely made without the benefit of any rigorous theory on his part, as was common in those early days of electrical technology. Nonetheless, Whitehouse was appointed Electrician to the Atlantic Telegraph Company, and was given responsibility for the testing of the Atlantic cable during manufacture, and its working once laid.

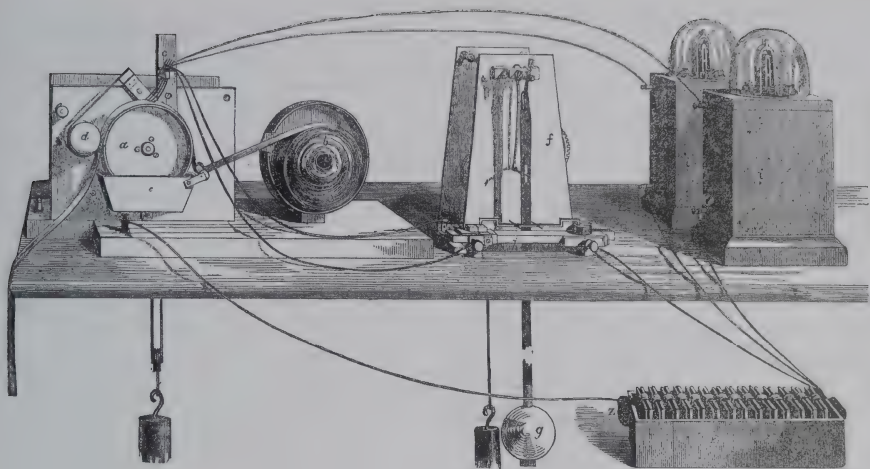


Fig. 1. Whitehouse's Velocity Measuring Apparatus (Illustrated London News 6 October 1855)

Whitehouse's experiments had led him to believe that high voltages were the answer to the poor conductivity of long cables, and he was supported in this by Faraday and Morse, whose names and reputations carried considerable weight at the time. Whitehouse built and tested a number of large induction coils operated by banks of electrical cells, and convinced the company that using a high voltage coil would allow speedy working of the Atlantic cable, and could even operate a

printing instrument at the receiving end.

This induction coil (Fig. 2), made by Whitehouse in the 1850s and now in the reserve collection of the Science Museum in London, is an amazing 36 inches long. It is believed to be similar to the one that Whitehouse used to work the Atlantic cable in 1858 – that one being even bigger, at five feet long, and generating pulses of up to 2000 volts. The coil was powered by a very large battery, designed

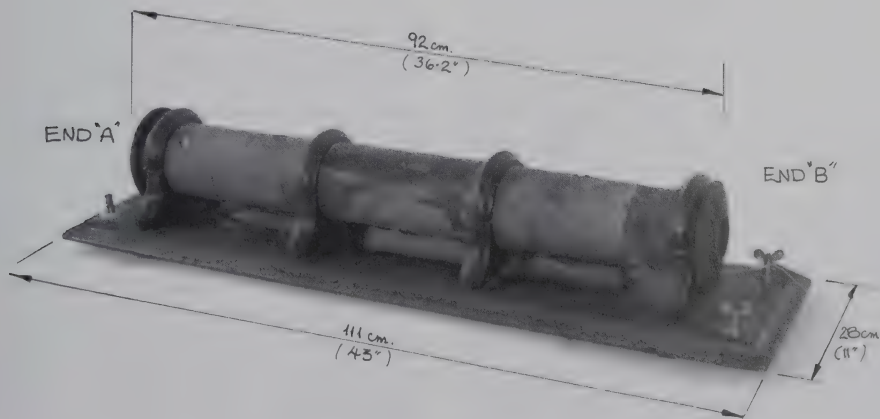


Fig. 2. Whitehouse 36" Induction Coil (Science Museum, London. Photo: Allan Green)

by Whitehouse and described as “a giant voltaic battery, of ten capacious cells,” each cell having “2,000 square inches of silver, and 2,000 square inches of zinc.” Unfortunately, no images of this immense power source have ever been recorded. (Atlantic Telegraph Company, 1857).

Using his induction coil, Whitehouse was able to read signals through the 1858 cable with a standard galvanometer made by W.T. Henley’s Telegraph Works Company, one of the earliest telegraph instrument makers (Fig. 3a). This historic galvanometer, which received the first signals ever transmitted across the Atlantic, was presented by the Atlantic Telegraph Company to its Secretary, George Seward, in December 1858, and is now at the Science Museum in London (Fig. 3b). It is accompanied by a letter signed by C.W. Lundy: “I certify that I received on this Instrument the first words transmitted from America through the Cable of the Atlantic Telegraph Company, at 1.48 am Greenwich time, 10th August 1858.” (Science Museum MS 1391)

William Thomson, meanwhile, although not employed by the Atlantic Telegraph Company, was asked to consult on various technical matters. He was unpaid, and had no responsibility for the laying and working of the cable, this being the job of Whitehouse. However, showing considerable business acumen for an academic, Thomson had already started taking out patents on technology he thought would be useful in the cable industry, a policy he continued throughout his career, and which made him a very wealthy man. He took the opposite approach to Whitehouse, and between 1856 and 1858 developed a much more sensitive version of the standard



Fig. 3a. 1858 Henley Galvanometer (Science Museum, London #1919-349. Photo: Ivor Hughes)

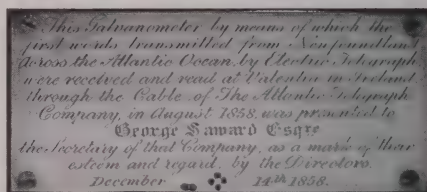


Fig. 3b. Detail of Plaque

galvanometer, using a tiny mirror mounted on the coil to magnify the very small movements of the meter when used on a long cable. Thomson based his galvanometer on earlier instruments, but reduced the moving mass to a fraction of that previously achieved, making it into a practical instrument for cable use (see Fig. 4).

Thomson was issued British patent No. 329 of 1858 for his mirror galvanometer, which he test on land prior to the 1858 Atlantic cable voyage. Whitehouse was supposed to sail on the *Niagara* with the cable expedition, but



Fig. 4. Thomson Mirror Galvanometer used at Valentia, 1858 (Science Museum, London #1907-105)

backed out and was replaced by Thomson, who used his marine mirror galvanometer to receive signals over the cable on board ship while it was being laid (Fig. 5). Whitehouse remained at Valentia, and once the cable was laid, in his official capacity as Electrician of the project he insisted on using his high voltage equipment on the cable. For a short time he was able to read signals sent from Newfoundland to Ireland using the Henley galvanometer, but the cable soon began experiencing problems and Whitehouse had to use the mirror galvanometer to read anything at all, although he did not mention this in his reports to the directors. (Report of the Joint Committee, 1861)

After the early failure of the 1858 cable, attributed to Whitehouse's extremely high voltages breaking down the insulation in some sections of the cable which had deteriorated in storage prior to being laid, the use of induction

coils was completely discredited. Thomson's mirror galvanometer became the standard receiving instrument, allowing even long cables to be worked on just twenty or thirty volts of battery power. Mirror galvanometers also came into widespread use as precision laboratory instruments, a role they filled until the development of digital meters a hundred years later.

The mirror galvanometer was key to the efficient working of long cables, and as it was such an important development, it is worth reproducing here a 19th century account of its operation. (Munro, 1891):

"The mirror galvanometer consists of a long fine coil of silk-covered copper wire. In the heart of that coil, within a little air-chamber, a small round mirror is hung by a single fibre of floss silk, with four tiny magnets cemented to its back. A beam of light is thrown from a lamp upon the mirror, and reflected by it upon a white screen

or scale a few feet distant, where it forms a bright spot of light.

"When there is no current on the instrument, the spot of light remains stationary at the zero position on the screen; but the instant a current traverses the long wire of the coil, the suspended magnets twist themselves horizontally out of their former position, the mirror is of course inclined with them, and the beam of light is deflected along the screen to one side or the other, according to the nature of the current. If a positive electric current gives a deflection to the right of zero, a negative current will give a deflection to the left of zero, and vice versa.

"The air in the little chamber surrounding the mirror is compressed at will, so as to act like a cushion, and deaden the movements of the mirror. The needle is thus prevented from idly swing-

ing about at each deflection, and the separate signals are rendered abrupt and "dead beat" as it is called.

"At a receiving station the current coming in from the cable has simply to be passed through the coil before it is sent into the ground, and the wandering light spot on the screen faithfully represents all its variations to the clerk, who, looking on, interprets these, and cries out the message word by word.

"The small weight of the mirror and magnets which form the moving part of this instrument, and the range to which the minute motions of the mirror can be magnified on the screen by the reflected beam of light, which acts as a long impalpable hand or pointer, render the mirror galvanometer marvellously sensitive to the current, especially when compared with other forms of receiving instruments." (Fig. 6)

The problem of the cable's very high capacitance smearing the signal also needed to be addressed. This was resolved at least well enough to give a working speed of a few words a minute by using positive and negative voltages to represent dots and dashes (as Munro describes above), instead of the same-voltage pulses of different lengths used to send standard Morse code on land lines. By grounding the cable between each transmitted pulse, the elements of each character could be read at the receiving end using the mirror galvanometer, which would deflect in one direction for a dot and the other for a dash.

The use of positive and negative voltages required a special key with two levers, fitted with contacts to send the appropriate polarity as each lever was depressed, and to ground the cable between each signal. This became known as a

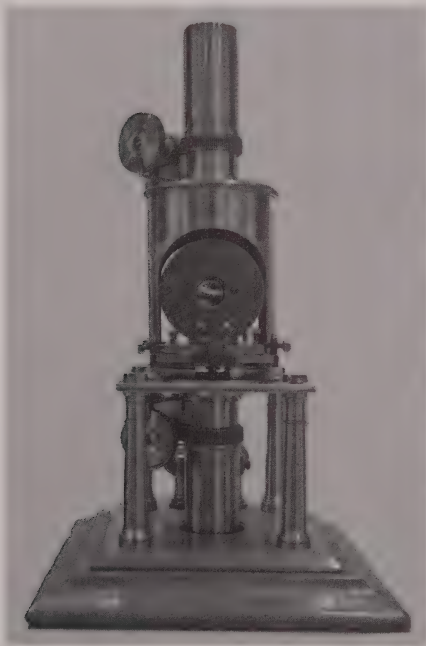


Fig. 5. Thomson Mirror Galvanometer used on HMS Niagara, 1858 (Science Museum, London #1876-41)



Fig. 6. Mirror galvanometer setup showing oil lamp, collimator, mirror galvanometer, and scale. (Garnham & Hadfield, *The Submarine Cable*)

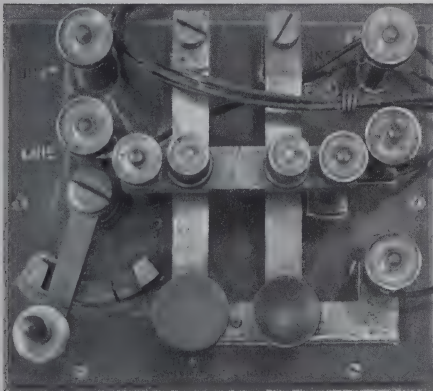


Fig. 7a. A well-used Silvertown Cable Key (French Cable Station Museum, Orleans, Massachusetts)

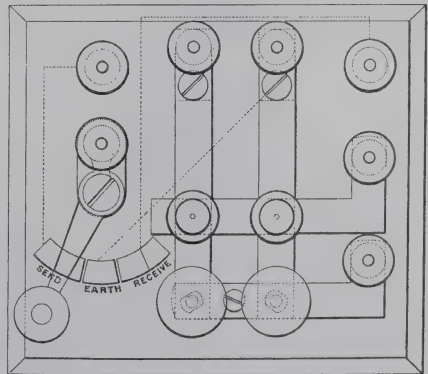


Fig. 7b .Cable Key Diagram (Bright, 1898)

cable key, and the design remained in use throughout the life of telegraph cables, well into the 1950s (Figs 7a, 7b).

The disadvantage of the mirror galvanometer was that it required

two operators, one with a steady eye to read and call off the signal, the other to write down the characters received. Thomson again provided a solution with his siphon recorder, effectively an

ink-jet printer, for which he was issued British patent No. 2147 in 1867, and licensed it to the cable companies. Where the mirror galvanometer used tiny magnets suspended in a large coil of wire, the siphon recorder employed a light coil suspended between the poles of a large magnet. The effect was the same; the positive and negative signals from the cable caused the coil to move left or right from its rest position. Attached to the coil was a fine glass tube, which was immersed in a trough of ink at one end and poised just above a moving paper tape at the other. The tube could not touch the paper tape, as this would impede the motion of the coil, so the trace was written on the paper by an ingenious method - the ink siphoned up through the glass tube and was sprayed onto the paper tape by an electrostatic charge generated by a device called

a "mouse mill," running next to the siphon recorder (Fig. 8).

Because of their high sensitivity, it was essential that siphon recorders be of solid construction and isolated from their surroundings. Most were built on a solid brass bedplate, and when used at a cable station the instrument would be mounted on a support which bypassed the building's structure and mounted directly to the ground below. At the French Cable Station Museum in Orleans, Massachusetts, it is reported that the siphon recorders there could detect the unloading of coal from a rail freight car several blocks from the cable station. In the remote locations of most cable stations the operators could not send for spare parts in an emergency, so they became skilled at drawing siphon tubes from standard glass tube using a Bunsen burner to heat the

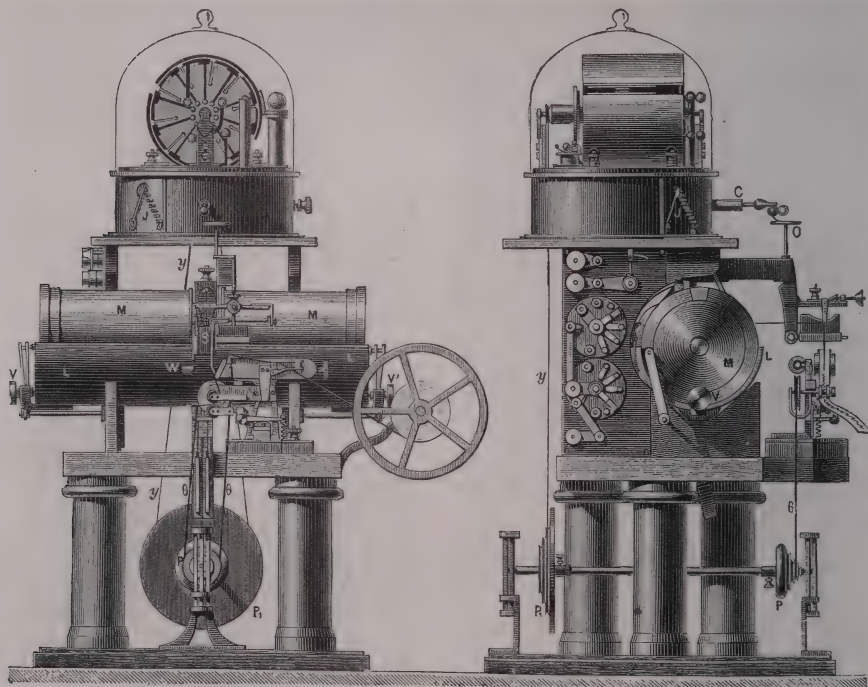


Fig. 8. Siphon Recorder with Mouse Mill (Bright, 1898)

glass, and also made other parts as needed.

Thomson's siphon recorder was first used on the French Atlantic cable at St Pierre, off the coast of Newfoundland, in 1869, and came into general use in the 1870s. It allowed unattended recording of the received signal, and also created a permanent record of each message on the paper tape, or slip, which after transcription for forwarding or printing could be filed in case of later queries. In some parts of the world extreme humidity caused problems with the electrostatic charge, and on later versions of the siphon recorder the tube contacted the paper and a mechanical vibrator was used to reduce the friction (Fig. 9). Like the cable key, the siphon recorder remained in use as a standard instrument throughout the life of telegraph cables. (Bright,

1898)

The importance of the siphon recorder, which gradually replaced the mirror galvanometer, may be understood from the royalties attached to its use. Thomson charged the cable companies 10 shillings per nautical mile of the cable for the right to use the siphon recorder – the equivalent of about \$2 per mile at the time, or over \$4000 for a typical Atlantic cable. Thomson's patent rights in the instrument persisted until 1882. (Bright, 1898).

Because of the high capital cost of laying and working ocean cables, the operating companies needed to maximize the message throughput in order to obtain the best return on their investment. Until the 1870s, submarine cables could be worked in only one direction at a time. On land, duplex and even

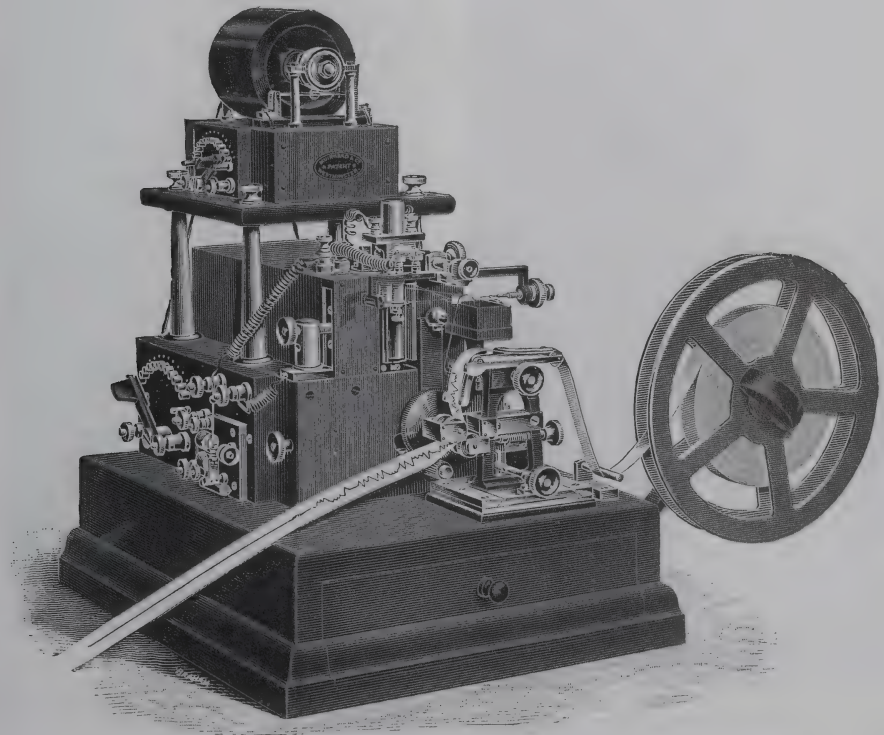


Fig. 9. Muirhead Siphon Recorder with Vibrator (Bright, 1898)

quadruplex techniques allowed multiple message to be carried simultaneously over a single line, but as with everything else, the solution for submarine cables was more complex.

Duplexing involves using the telegraph line as one arm of a Wheatstone bridge, and balancing it by means of variable resistances. The indicating instrument is then placed across the diagonal of the bridge, and is unaffected by the outgoing signals, responding only to signals from the distant end of the line. (Bright, 1898)

While the principle of duplexing was the same, the complex electrical characteristics of cables and the very sensitive instruments used to work them made the implementa-

tion far more difficult. Instead of simple resistances, the cable had to be balanced by what became known as an artificial line, an array of resistances, inductors, and condensers which had to be constantly adjusted as the cable's characteristics changes with varying temperature and electrical conditions. By the late 1870s artificial lines were in use on the high-traffic circuits across the Atlantic, effectively doubling their message capacity (Fig. 10).

As siphon recorders replaced mirror instruments, hand keying became too slow, so the next development was the automatic transmitter. Like the siphon recorder, these operated on paper tape, but for transmitting the tape was punched with a series of timing holes down its center, on either side of which were holes representing positive and negative signals, or dots and dashes. The tape was fed into an automatic transmitter which by means of the timing track moved the tape at a constant rate and translated the holes into the appropriate voltages to be transmitted over the cable.

Charles Wheatstone, the originator of telegraphy in Britain, had patented the first automatic transmitter for landline telegraphy in 1858, but it again took time to adapt the instrument for cable use, which was done in the late 1870s. The cable sender is more complicated than its landline counterpart, as it must "curb" the signals in a similar manner to the grounding of the cable between signals by the cable key. In the cable sender this was done by sending a positive current followed by a negative, or vice versa, for dots and dashes. The first senders worked at about 30 words per minute, but the speed was limited only by the performance of the cable, and by

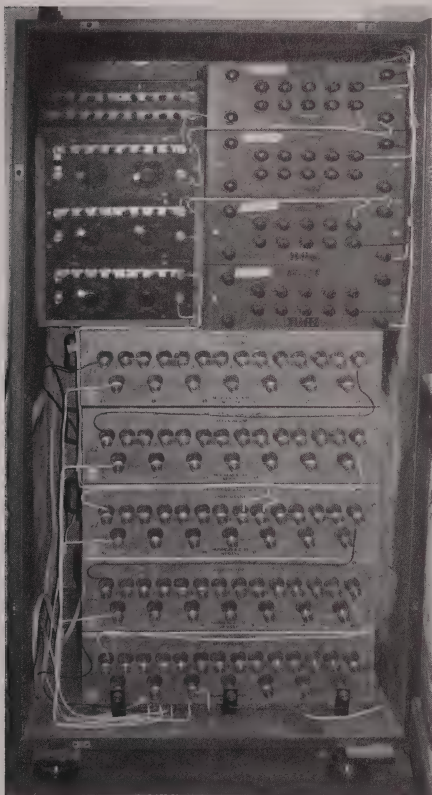


Fig. 10 Artificial Line (French Cable Station Museum)

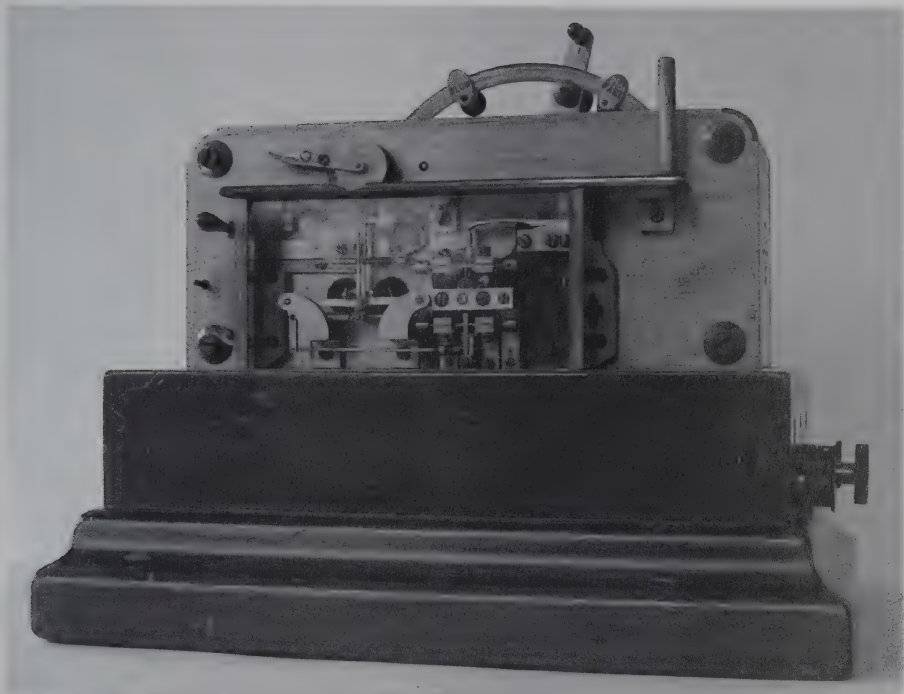


Fig. 11 Wheatstone Transmitter (Photo: Fons van den Berghen)

the turn of the century improved instruments achieved speeds of up to 100 wpm. (Bright, 1898; Fig. 11)

To make the holes in the tape for outgoing messages a number of instruments were devised. The simplest was the mallet or manual perforator (see Fig. 12).

This was operated by striking the left or right lever with a small mallet, causing either a dot-hole or dash-hole to be punched in the message tape, while striking the center lever made a space. Each punching operation also created a smaller timing hole along the center of the tape. A typical long cable was served at each end by four operators punching tape, and a fifth feeding it into the transmitter. Cable message tape was known as "slip" (Fig. 13).

In 1893 Patrick B. Delany invented an electro-magnetic perforating machine, comprising a key with three light levers similar

to the lightest form of cable keys. The buttons of these levers were grouped in clover form—dot, space, and dash. An electro-magnet operated the dot punch, another the dash punch, and a third the spacing of the signals. A skilled operator could punch tape with far less effort than using a hand punch, but still at a relatively slow rate. (Bright, 1898).

Mechanisms based on the type-writer were eventually adopted for punching tape. By the early 1900s keyboard perforators became available and around 1910 both Kleinschmidt and Creed introduced perforators which became the standard devices. Now a single operator could punch a tape which fed directly into the cable transmitter. These keyboard perforators were the predecessors of the Teletype machine, which became the last vestige of the telegraph system to be abandoned in the late 20th

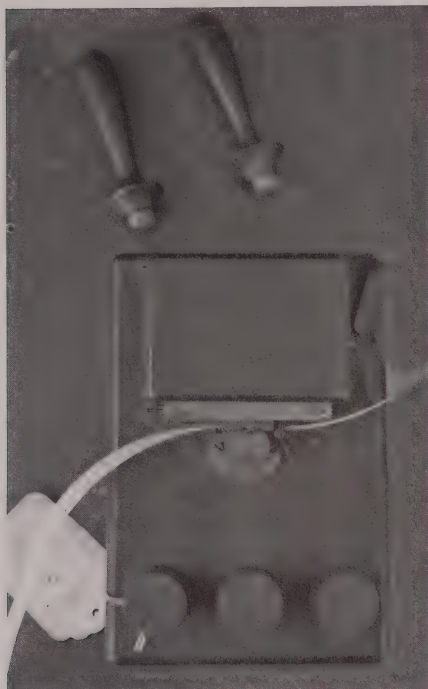


Fig. 12 Mallet Perforator (French Cable Station Museum)

century (Fig. 14).

Before the invention of the vacuum tube and the beginning of its widespread use in the 1920s there was no way to amplify signals electronically, so the ever-ingenuous cable engineers devised a variety of electromechanical relays and amplifiers, or “magnifiers” as they were called. Two instruments commonly used on long cable circuits were the Heurtley Magnifier and the Brown Drum Relay, both invented in the early 1900s. These instruments were the pinnacle of electro-mechanical technology, probably some of the most sophisticated such instruments ever devised, the work which went

into their design and manufacture being an indication of the revenue which could be generated by even small improvements in the worldwide cable system.

Like the siphon recorder, these relays were very sensitive instruments mounted on heavy bases (a Brown Drum Relay weighs over a hundred pounds), and they were generally installed in the same way - on steel supports or solid columns connected to a concrete foundation independent of the building's structure (Fig. 15).

The Heurtley magnifier addressed the problem of the signals on long loaded lines being insufficient to operate even a siphon recorder. It was patented by E.S. Heurtley in 1909 and used the siphon recorder design of a light coil suspended in a magnetic field to move the working element. But in a most ingenious arrangement, the instrument also incorporated a Wheatstone bridge. As can be seen from the diagram, two platinum wires are mounted on an aluminum cradle, which follows the movement of the coil (Fig. 16). The wires form two arms of the Wheatstone bridge and are heated by current from a battery. Adjacent to each wire is a tube carrying a stream of cold air, with a slit along its length. The tubes are arranged so that a deflection of the coil in one direction brings one wire into the air blast and removes the other from it, a deflection in the opposite direction having the opposite effect. The temperature change in the wire from the air blast causes its resistance to change, unbalancing the bridge and allowing a larger signal to flow across its diagonal,



Fig. 13 Cable Slip. Dots above the center line, dashes below.

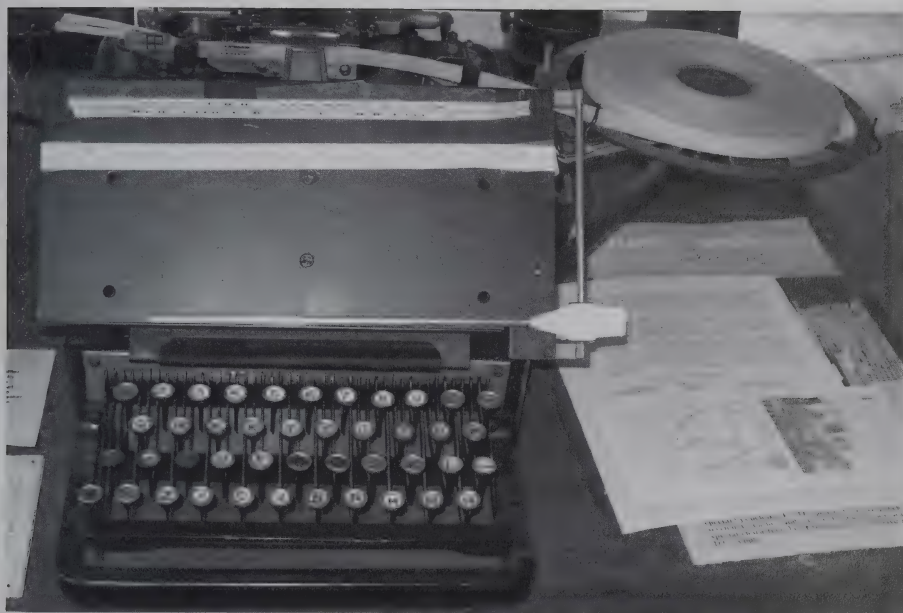


Fig. 14 Kleinschmidt Perforator (French Cable Station Museum)

sufficient to operate a recording instrument. It was reported in 1912 that a Heurtley magnifier allowed a duplex cable's speed to be increased from 135 to 190 letters per minute. (Malcolm, 1917).

In a variation of the original design, a later version of the Heurtley magnifier used four platinum wires connected as two arms of the Wheatstone bridge; one fixed and one movable wire in series as one arm, and the other pair as the other arm. Movement of the coil causes the two movable wires to move in relation to the two fixed wires, causing one moving wire to be closer to its fixed partner, and the other to be further away. All of the wires are electrically heated, and in consequence the temperature of the close pair rises, and that of the distant pair falls. Similar to the air blast effect describe above, this again changes the resistance in the wires and unbalances the bridge, with the same result. (Clokey, 1936)

A related problem was the

onward transmission of the tiny signals received over the cable. Using a siphon recorder or magnifier there was no way to relay messages onto another cable or a land line without re-keying - a time-consuming and error-prone procedure.

The Brown Drum Relay again used the basic principle of the siphon recorder, but instead of a siphon tube the galvanometer coil carried a tongue consisting of a light glass tube through which passed a fine platinum wire tipped with iridium. Moving left or right according to the signal polarity, the end of the wire rested on a spinning drum, about three inches in diameter. This drum, rotated by a motor at a speed of about 150 revolutions per minute, was built up of three silver rings. The center ring was insulated from the others by thin mica discs and formed a neutral portion on which the tongue rested when no signals were passing. The effect of spinning the drum was to greatly reduce the friction on the

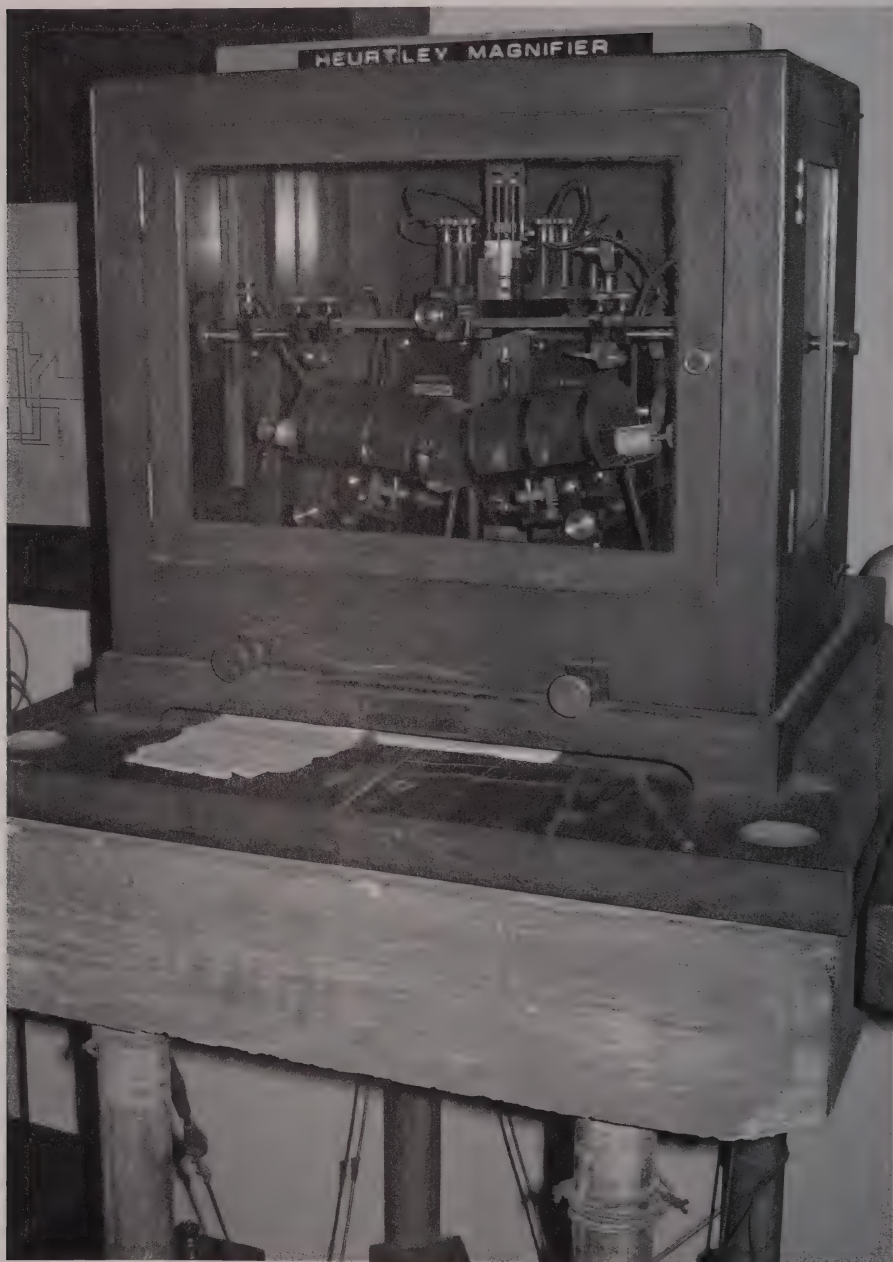


Fig. 15 Heurtley Magnifier on supports (French Cable Station Museum)

tip of the contact wire, allowing the very small signal currents to move it freely from side to side. As the tip of the wire contacted either the left or right silver surface, this switched a higher voltage signal

which could then be relayed onto another circuit. (Eastern Telegraph Company, 1928; Fig. 17).

The final development in telegraph cable signalling was electronic amplification, starting in

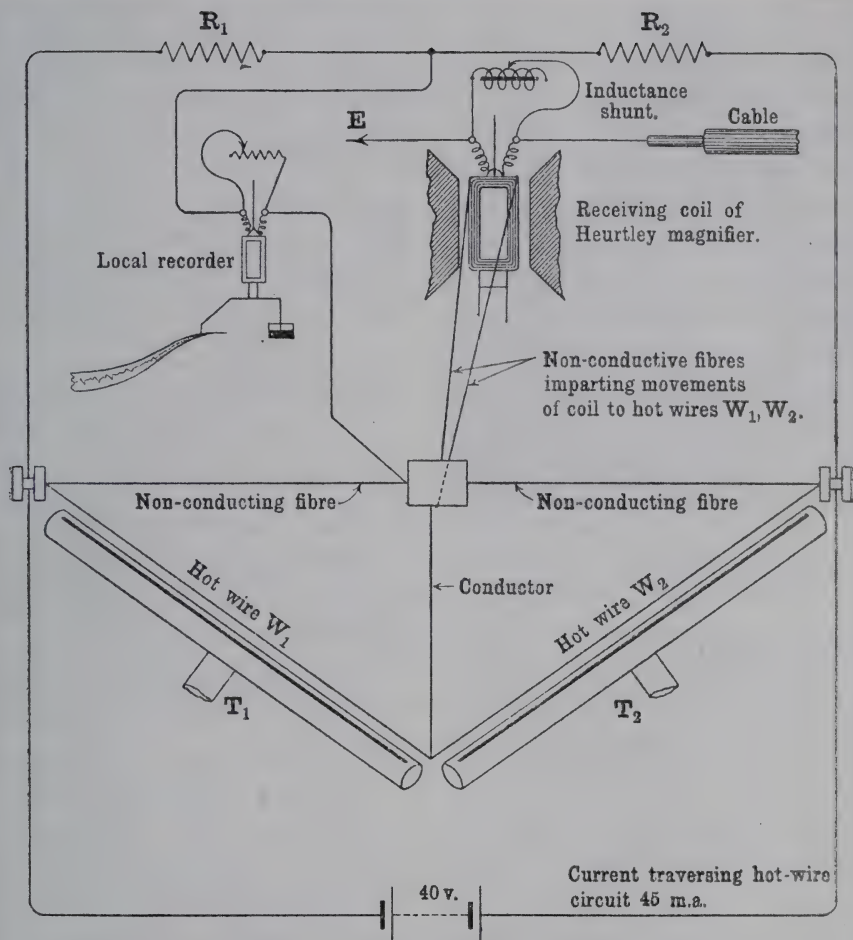


Fig. 16 Heurtley Magnifier diagram (Malcolm, 1917)

the 1930s. But despite this availability of vacuum tube equipment for undersea circuits, many of the electro-mechanical instruments continued in use at remote cable stations worldwide for another twenty years or more, as they were reliable, familiar, and relatively easy for the operators to maintain on site.

Once a repeatered submarine telephone cable had been laid across the Atlantic in 1956, a single voice circuit could be used to carry multiple telegraph channels, and by the mid 1960s all the telegraph

cables had been taken out of service and the stations closed. The era of brass and mahogany was finally over, and the instruments which had served so well for the best part of a century are now found only in museums or private collections. Those very few cable stations which themselves became museums after closing in the 1960s are now the only places to see how the instruments were actually installed and operated.



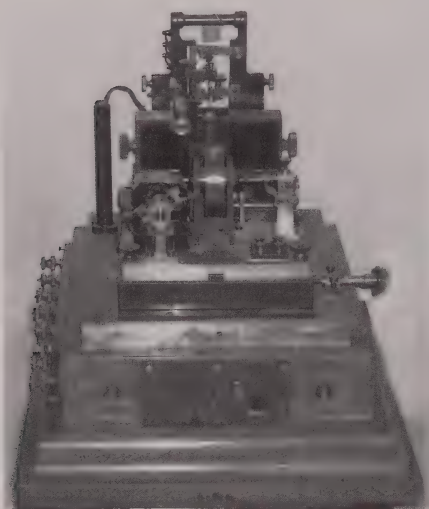


Fig. 17 Brown Drum Relay. This instrument is about 16" wide across the base and weighs over 100 lbs.

AFTERWORD

This article has touched on only the highlights of the first 70 years of submarine telegraphy and describes only a handful of the many instruments and variations used in submarine telegraphy into the first decades of the 20th century, the end of the pre-electronic era in cable communications. I believe it is fair to say that the scientists and engineers responsible for the achievements of the first sixty years of the cable industry laid the foundation for the modern field of electronic engineering, which has seen communications technology progress in a direct line from the first telegraph cables of the 1850s to the worldwide fiber optic submarine cable network which carries almost all of today's Internet, voice, video, and data communications traffic.

A much more detailed survey of the development of the industry from its beginnings in 1850 until the late 1890s may be found in Charles Bright's *Submarine Telegraphs: Their History, Construction, and Working*, published in

1898, which has over 300 pages on the technology involved. Printed copies are scarce and expensive, but the full text (for American readers, at least) may be viewed at Google Books.

REFERENCES

Note: The full text of references marked [AC] may be found on the Atlantic Cable website at <http://atlantic-cable.com>

- Atlantic Telegraph Company. *The Atlantic Telegraph: A History of Preliminary Experimental Proceedings*, Atlantic Telegraph Company, London, 1857.
- Bright, Charles. *Submarine Telegraphs, Their History, Construction and Working*, Crosby Lockwood, London, 1898.
- Clokey, Allison A. 'Submarine Cable Telegraphy', 1936. [AC]
- Eastern Telegraph Company, *Textbook on Telegraph Cable Engineering*, Waterlow & Sons Limited, London, 1928.
- Elmquist, Randolph E., Marvin E. Cage, Yi-hua Tang, Anne-Marie Jeffery, Joseph R. Kinard, Jr., Ronald F. Dziuba, Nile M. Oldham, Edwin R. Williams. *The Ampere and Electrical Standards*, Journal of Research of the National Institute of Standards and Technology, Jan-Feb, 2001.
- Field, Henry M. *History of the Atlantic Telegraph*, New York: Charles Scribner & Co., 1866.
- Garnham, Capt. S.A. and Robert L. Hadfield, *The Submarine Cable: The Story of the Submarine Telegraph Cable from its Invention down to Modern Times*, Sampson, Low, Marston & Co. Ltd., London, ca. 1934
- Malcolm, H.W. *Theory of the Submarine Telegraph and Telephone Cable*, Bann Brothers, London, 1917.
- Munro, John. *Heroes of the Telegraph*, Religious Tract Society, London, 1891.
- Report of the Joint Committee Appointed by the Lords of the

Committee of the Privy Council for Trade and the Atlantic Telegraph Company to Inquire into the Construction of Submarine Telegraph Cables together with the Minutes of Evidence and Appendix, London, 1861. Evidence of Wildman Whitehouse, 15 December 1859. [AC]

Thomson, William (1855). 'On the theory of the electric telegraph', *Proceedings of the Royal Society of London* (May 1855), reprinted in Thomson, *Mathematical and Physical Papers*, Cambridge, 1884.

Thomson, William (1856). Letters to the *Athenaeum*, October and November 1856.

Whitehouse, Wildman. *Report of a Series of Experimental Observations on Two Lengths of Electric Cable, Containing, in the Aggregate, 1,125 Miles of Wire*, Privately published, Brighton, 1855. [AC]

ABOUT THE AUTHOR

Bill Burns is an English electronics engineer who received a Bachelor of Science degree from the University of Leeds in 1968. He worked for the BBC in External Services Radio for three years, then moved to New York in 1971 after meeting his American future wife in London. He spent a number of years in the high-end audio industry at a Long Island company, during which time he also reviewed equipment and wrote articles on audio, video, and computers for a group of consumer magazines. Turning to computers full time in the late 1970s, he worked on both hardware and software, and in 1993 he established his own computer consulting business, which still occupies much of his time.

His research for ar-

ticles on subjects as diverse as audio recording and reproduction theory, video tape recorder development, electronic music instruments, and the history of computing, led to a general interest in early technology. In the 1980s he began collecting instruments and artifacts from the fields of electricity and communications, and in 1994 a chance find of a section of the 1857 Atlantic cable led to his specialization in undersea cable history.

In 1995 he set up the first version of the Atlantic Cable website <<http://atlantic-cable.com>>, initially just a single page with a bibliography of books on undersea telegraphy. As he acquired more material - cable samples, instruments, books, documents, and other artifacts - each new find was added to the site, which now has over 850 pages on all aspects of undersea communications from 1850 until the present. Many site visitors have also contributed photographs, stories, and articles, and in several cases long-lost relatives and friends have been re-united through the website.

Bill's interest in cable history has taken him to cable stations at Heart's Content (Newfoundland), Valentia and Waterville (Ireland), Porthcurno (Cornwall) and Orleans (Cape Cod, Massachusetts), and to archives and museums in New York, Washington and Key West in the USA; London, Edinburgh, Manchester and Hull in Britain; and others in a number of European countries. He has presented papers on cable history to an IEEE/IEE conference at University College London, at cable company Iberia Atlantic's annual meeting, at the 150th Anniversary Celebration for the 1858 Atlantic cable at the New-York Historical Society (which he

Submarine Cable Instruments

instigated and helped organize), and at the AWA Conference for the last two years.



Bill Burns in cable-hunting mode.

British World War Two Army Anti-Aircraft Radar

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ABSTRACT

British Army anti-aircraft radar of World War II and years immediately thereafter is described. The earliest mid-1930s developments are examined briefly as is the work leading to the cavity magnetron's introduction and consequent centimeter wave radars. Operational devices from 1940 to 1950 are described in some detail with line drawings, examples mainly being taken from the former Anti-Aircraft Command School of Technical Instruction at Lydd in Kent, a unit of the Royal Electrical and Mechanical Engineers. Accurate Position Finders included British designed and manufactured meter-wave Gun Layers of 1940 to 1942 are considered, and 10 cm magnetron equipment from the last months of WW II, and also the American designed and supplied SCR-584s. Early-Warning units described include the famous Canadian Zippy system, and a remarkable D-Day unit assembled at short notice from available Army, Navy and Royal Air Force equipments.

While British Royal Air Force radars are fairly well cataloged, less material has appeared on army equipment, so I will attempt here to improve the balance. The British army's Anti-Aircraft Command was by 1950 the inheritor of a wide range of radars, from earlier British developmental sets, through to British, US and Canadian models operational in that year. Many of these were to be seen, and worked on, at the Anti-Aircraft Command School of Technical Instruction (AACSTI), the then fairly familiar name of the Command's technical training school. At Crookham in Hampshire until 1948, and at Lydd in Kent from then until it was disbanded in 1955, AACSTI was a small unit of the Royal Electrical and Mechanical Engineers, (R.E.M.E.). It was responsible for training craftsmen as Telecommunication Mechanics (or Telemechs) for work on A.A. radars, and also as Electricians, Control Equipment (ECEs, pronounced "Eckies"), who worked on predictors and A.A. guns. Other arms, such as Coastal Command, were served by the main R.E.M.E. technical training unit at Arborfield in Berkshire.

The equipment inventory of Lydd's Radar Wing, maybe thirty units in total, used tubes throughout, was all mobile and mounted in trailers, which were generally in the two to ten ton range. In age it varied from meter-wave systems designed and built in the late 1930s and early 1940s, to centimeter-wave equipment from the end of World War Two, mainly British in design and construction, but with a very important element from the U.S.A. and Canada. In 1951 about three-quarters of them were in a current operational status, though obsolete and obsolescent radar types were represented. However, Anti-Aircraft Command with its striking insignia of a black cross-bow firing upwards against a red background, would not exist very much longer. Within just a few years, the task of ground-based aircraft interdiction had been ceded to missile systems, which were operated

by units of the Royal Air Force. Anti-aircraft guns, searchlights, radars and predictors were largely retired from the British military scene, except for airfield defence which was the remit of the Royal Air Force Regiment. A few of these radars thereafter saw service in such tasks as weather sonde tracking, some reputedly even being sold and relocated as far afield as Pakistan.

DEVELOPMENT

The birth of radar is today sufficiently far in the past, that for many readers it will be worthwhile to look briefly at the sequence of its development from the very earliest operations in the meter-wave region, through to the centimeter wave equipment characteristic of the 1950s and beyond.

Although earlier work had been done in other countries, detecting ships and navigational obstacles for instance, with some fair success, the driving force in Britain was the question of defense against bombing raids by European-based aircraft. In the mid 1930s, with an almost complete absence of funding for military work, there were schools of thought which varied from "*the bomber will get through*" to a determination to detect and locate enemy aircraft by their sounds, or even by their infrared emissions. However, the now well known, but then top-secret demonstration in February 1935 by Robert Watson-Watt, that reflected radio waves might be more than just feasible as a method of aircraft detection was the jumping-off point for a long sustained spurt of development.

It was not at all easy to detect such reflections, as the fundamental laws of free-space propagation of radio waves must be applied, not once, but twice. Firstly, the field

strength of the radar transmitter's pulsed emissions falls off as the square of the distance. Secondly, the reflected wave coming back from the target aircraft, small to start with, is itself subject to the same square law diminution. The overall effect is expressed in the "*radar equation*" which tells us to expect the signal at the receiver to fall off as the fourth power of the distance from radar to target.

Additionally, for an aircraft to be a competent reflector, the wavelength to be reflected should be at least comparable with, and preferably rather less than its greatest dimension, presuming a conducting metallic structure, generally true by 1939. In that year a typical bomber might have a wingspan of some seventy to one hundred feet, so that short waves of some 30 MHz would be a reasonable initial selection. But other criteria needed to be satisfied too. The higher the available transmitter power, the better, though 30 MHz was also something of a maximum working frequency for conventional tube transmitters of the 1930s.

On the other hand, any possible antenna gain would help both outgoing and incoming signals, and the shorter the wavelength, the smaller and easier the antenna construction, with the additional concern that any sort of steerable beam was extraordinarily difficult to provide at frequencies much below 50 MHz. Today's Yagi antenna was still a novel concept, coaxial cables for radio frequency use were still in their very early infancy, and polyethylene was not commercially available at all until the late 1930s, after ICI's fortuitous discovery in 1933. Gutta percha, for example, was not a wonderful alternative!

Several distinct approaches followed. From 1939-1940 conventional technology built the famous

Chain Home (CH) radars, some fifty of which with their 300 ft. steel transmitting towers and 240 ft. wooden receiving antenna towers were notable features of the British coastline from 1939 well into the 1950s. They operated at from 20 – 30 MHz, with peak power of 250 – 750 kW and a pulse repetition frequency or p.r.f. of 25 pulses per second, which very low rate allowed synchronization for minimizing inter-station interference. But such a system, operated by the Royal Air Force for the direction of fighter aircraft at relatively long ranges over the North Sea, offered no sort of answer to the Army's need for mobile equipment which could provide guidance for anti-aircraft guns, where sound locators, either fixed or mobile, had unfortunately proven almost useless.

Therefore, although there was emphasis on the development of tubes capable of operating at much higher frequencies, the first provision was of mobile radars which operated around 50 MHz. Further development of conventional tubes soon raised the practical maximum frequency to around 200 MHz.

A quite different advance followed the development of the magnetron. While its predecessors, essentially diodes operating in a strong magnetic field, were first built by A.W. Hull at General Electric (GE) in 1920, it was not until 1940 when Randall and Boot built a multi-resonant-cavity version at the University of Birmingham in England that a stable device capable of producing very high power at ultra-short wavelengths became possible. Subsequent development and manufacture occurred mainly in the USA, following an often-told and dramatic technology transfer. Although other tubes such as the klystron were rapidly developed too, magnetrons largely drove

the move to microwave systems, which became a major focus in both countries. Anti-aircraft radars using an operating wavelength of 10 cm. and 3000 MHz frequency soon became commonplace after about 1941, enormous improvements in antenna gain and much narrower beamwidths becoming feasible as parabolic reflectors of practicable dimensions could be used.

Other developments considered central to the full deployment of Automatic Position Finding (APF) radars were those of “*lock-on*” and “*auto-following*”. The earliest meter-wave equipments could only follow an aircraft by manually bracketing, or moving the radar's beam slightly from side to side and comparing the height of the received target blip on an A-scan tube as it diminished when the beam moved off-target in each direction.

This operation was automated in 200 MHz equipment such as “*Elsie*” by providing four directional Yagi receiving antennas, switched mechanically so as to be used in continuous rapid succession, notionally deflecting the beam up, right, down, left in sequence. Comparing and balancing left and right signals, an operator could move the entire assembly manually in azimuth and so keep it pointed at a moving aircraft, the elevation operator doing the same with the up and down signals. With centimetric radars, beam rotation was easier in principle. The receive antenna if separate, and the combined antenna if not, was rotated at a few hundred r.p.m. and a switch directed the up, right, down and left elements of the signals to the appropriate servo amplifiers and displays. With the earlier equipments, a third and senior operator moved a strobe pulse, delayed in time from the instant of transmitter

pulse firing, and shown with the target blips on the A-scans for all three operators. The bearing and elevation positions thereby knew that they and the range operator were all looking at the same target!

The hand-wheel driven potentiometer which moved the strobe was coupled to a magstrip transmitter [a rotary transformer for relaying angular shaft position] and so the three positional elements of range, bearing, [or azimuth], and elevation were available as low voltage AC electrical signals. From the radar they went first to a predictor, an electro-mechanical analog computer, and then to the powerful electro-hydraulic servo mechanisms used to position the anti-aircraft guns. Range data, calculated from the range strobe delay potentiometer's position signal, was routed to a "Machine, fuse-setting" (MFS) which automatically cut the shell's fuse to length as each round was loaded, so that the shell would explode at the time, and therefore at the altitude, worked out by the predictor.

In early examples of APF automation, the bearing and elevation signals were gated so that the part representing the target blip was used, and they were then applied to servo systems which moved the radar antenna in "*auto-follow*" mode. However, for full automation, achieved by 1944 or 1945, a similar feat was also required in the range system. To do this, two range strobes were provided, one delayed slightly from the other, and the range potentiometer was servo-motor driven so that the portions of the signal blip gated by the two strobes were kept equal in magnitude. In service, the operators, three or four at first, later just one, would be informed of the approximate position of an incoming enemy aircraft, maybe still some

20,000 yards distant. This was relayed by magstrips, or often by wire-line field telephone, from an early warning or ZPI radar, also located on the A.A. gun site. The operators then moved the radar antenna in bearing and elevation to pick up the target, the range strobe was brought, also manually, to the position shown by the A-scan blips, and the equipment could then be "*locked-on*". Remarkably, it all usually worked!

NOMENCLATURE

At the outset of World War Two the entire field was, misleadingly and apparently deliberately, called Radio Direction Finding (RDF), and was top secret; the very name "*radar*" (Radio Detection And Ranging) had not been devised. The earliest British APF devices were known as Gun Layers, GL1 through GL3, with some variants. GL1 and successor GL 2's were meter wave sets. Magnetron based GL3's were the first of the centimeter wave heavy anti-aircraft (HAA) systems, used with 3.7 inch mobile and 5.25 inch fixed-site guns, and were three in number. The 3A was the very successful American SCR-584, the 3B was massive and British, entirely manually worked, normally by ATS operators (the British opposite numbers of US Army WAACs), while the unfortunate 3C, a Canadian radar, was reputedly declared obsolescent on landing in Europe.

By 1950 the 3C's at AACSTI were used only as a source of components for instructional purposes, and incidentally for our site amateur radio station. GL 1 & 2's became AA Radars No. 1 Mk 1 & 2, and GL3's A B & C became No. 3 Mk. 5, No. 3 Mk. 2 and No. 3 Mk. 1 respectively. The No. 3 Mk. 7 followed. AACSTI also had No. 2 searchlight-associated light

anti-aircraft (LAA) gear typically used with 40mm Bofors guns, and No. 4 early warning Radars. These latter included the remarkable No. 4 Mk. 5, but were otherwise No. 4 Mk. 6 MZPI's, a very successful Canadian contribution which entirely redeemed the ill-starred 3C. By 1950 the SECRET classifications had been reduced, although the Electrical and Mechanical Engineering Regulations (EMERs) which were our handbooks and service manuals, still contained typically dire warnings on confidentiality and sternly reminded users of their obligations under the Official Secrets Act.

NO. 1 RADARS

This category described pre-microwave units, operating in meter-wave frequency ranges, and already obsolescent by the end of European World War Two hostilities.

No. 1 Mk. 1 was the 1939 precursor of British APF radars, designed to track enemy aircraft and relay their position in azimuth and range by selsyn or magslip, or maybe by telephone, to gun crews. It comprised two dark green painted four-wheel trailers, the receiver with a turntable allowing the cabin to be rotated by a hand driven crank system. This comprised a pedestal with two handles similar to bicycle pedals, worked by an operator sitting behind it on something like a bicycle saddle. The transmitter operator was on her own, while the gyrating receiver cabin had at least two operators. All were usually female. One manipulated the cranks and controlled azimuth, and one determined range by reading the position of an aircraft echo "blip" on an A-scan CRT provided with a hand-calibrated scale. An ATS (later WRAC, Women's Royal

Army Corps) NCO controlled the operation from the receiver cabin, and handled the telephone. Some of these operators must have developed excellent upper arm physique, and they certainly had to acquire an immunity to quasi-sea-sickness. Six cabin revolutions per minute was an accepted maximum to help avoid that problem, but my personal experiences suggested that if used in an early warning mode, there could not have been any prolonged attempt at continuous rotation. Sector scanning might have been more practicable.

The main or receiver cabin, a wood and metal fabrication, had wooden lattice arms maybe 15 – 20 ft. long covered with wire mesh and extending to each side. On these arms were mounted dipole antennas forming a broadside array for any of 11 spot frequencies from 55 to 85 MHz. This provided sufficient directivity that the operator could determine incoming echo direction in azimuth, in the earliest days only by bracketing. In a later development, two blips, left and right, with different colors derived from a rotating filter arrangement known as the "*red-green monstrosity*", presumably phased with an electronic means of imparting a small horizontal antenna beam deflection, were compared, eventually on a dedicated vertical A-scan tube. No means yet existed for determining aircraft signal elevation angle.

The receiver cabin was fed with power, telecommunication and other circuits, through slip rings. The similarly constructed transmitter cabin had a large rack cabinet whose impressive transmitter with final tubes eventually D.C. pulsed to around 100kW peak, fed an equally unimpressive aerial up above the flat roof.

No. 1 Mk. 1* A slightly later

and higher powered version of the No. 1 Mk. 1, while its cohort, the "Radar (or GL) No. 1 Mk. 1 (Star) with 40 ft. tower", was equipped with a contraption known, with no love lost, as the "Bedford bastard", or less familiarly as the Bedford attachment. This was a very early attempt to obtain signal elevation data, using a further receiving dipole which could be moved up and down the 40 ft. tower to serve as a species of interferometer. The vertical movement used a rope and pulley system, the rope being pulled by one of the cabin operators. Bedford was a scientist with the Signals Research and Development Establishment (SRDE), and hailed originally from the Cossor company, famous in the UK for its test oscilloscope. His origin may support a contention that the "Bedford attachment" name was also applied to a device positioned over the front of a CRT in this radar, and probably intended to aid in elevation and height calculation. Any relation between this and the "*red-green monstrosity*" is unknown today.

No. 1 Mk. 2 In 1950, an example of Equipment R.D.F. (later Radar) A.A. No. 1 Mark 2 was still held on the battalion strength at Lydd (Fig. 1.). Known originally as the GL2, it was a development from the No. 1 Mk. 1, in which the movable elevation antenna had been replaced with a fixed elevated dipole. A goniometer in the receiver cabin was used to resolve the signals

and obtain the required elevation angle. This device is an accurately wound radio-frequency transformer, which can accept two inputs and output a combined fraction dependent on the angle of a rotatable winding. This can be used with two independent antennas, comparing their outputs relative to the rotor angle, to the same effect as physical rotation of a two-antenna system, the angle of the rotatable winding being equivalent to that of the antennas, and very much easier to organize physically! The transmit antenna was also now directional and so both cabins were rotated.

A point of some interest to users was the range calibration circuitry. A crystal oscillator was included to give a "pip" at regular intervals on the A-scan, and a "1000 yard" crystal provided a pulse for this purpose every 6.1 microseconds.

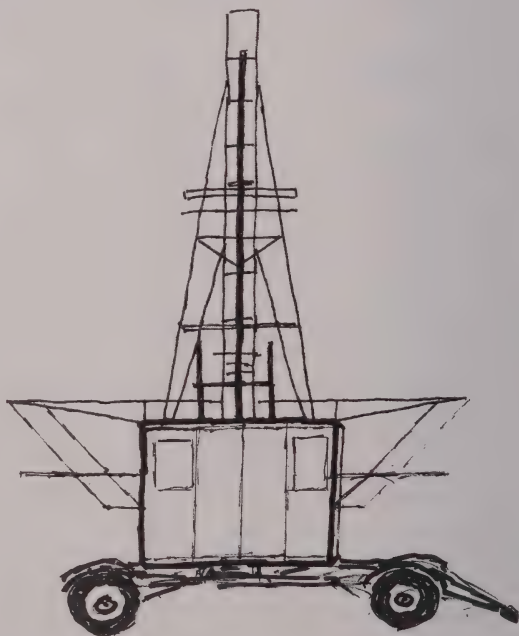


Fig. 1. No. 1 Mk 2, during set-up operations. The antennas may have been in the course of erection, as they were dismantled for transit. Wheels would normally have been removed during use.

One element of the design of such an oscillator was a trade-off between long term stability and easy starting. This particular crystal oscillator was notably stable, a fact which might have been recognized by the state of the painted front panel, where the scientific application of mechanical shock by a steel-shod army boot would have frequently helped a reluctant crystal to start. One item in the transmitter inventory was an earthing or grounding hook, permanently connected to chassis ground by a flexible cable, and intended to be hung on the high voltage D.C. bus whenever console doors were opened for cleaning or repair work. This was known as "Robinson's hook" after a one-armed janitor at the Signals Research Establishment, or so it was said.

It would be entirely too much to think of the No. 1 Mk. 2 as at all convenient in use. For instance, when one had to be moved on the highways, a considerable logistics exercise resulted. The antenna systems had to be disassembled and crated and sent to destination by truck, or possibly by rail, and then re-assembled on the new site. It was however considered to be very well designed and exceptionally robust, and GL2's certainly continued to give useful service long after they were completely technically outclassed by centimetric radars.

The drawing shows a No. 1 Mk 2 receiver cabin in the process of being readied for action. The chassis would

be steadied and raised somewhat with extended built-in jacks, and the wheels would often be removed. A wire mesh ground mat was also installed to provide the necessarily consistent reflection environment for the low VHF antenna system. The antenna configuration would surely have needed to change over the operating range of 55 to 85 MHz in operation, but no details are known to survive.

NO. 2 RADARS

These LAA. equipments were used for Searchlight Control or S.L.C. and known informally as *S Elsie* or just *Elsie* (Fig. 2). The earlier radars No. 2 Mk. 1 through 7 operated in the 200 MHz region with one of the first multiple arrays of Yagi aerials, and had ranges up to 22,000 yds. The later models Mk. 8 and 9 were centimetric, with a small dish antenna on 10 cm. The Mk. 9 did not reach ac-

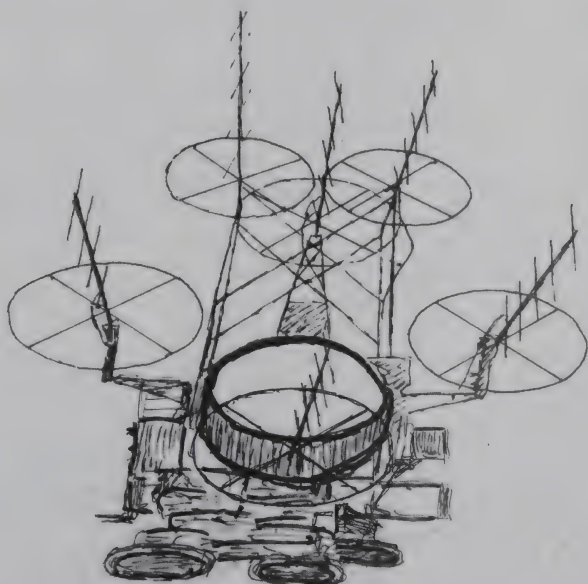


Fig. 2. An SLC Elsie searchlight-mounted 200 MHz radar, type number unknown. The four receive Yagis can be seen, also the transmit antenna and possibly an I.F.F. antenna. Not at Lydd.

tive service in World War Two. All were relatively lightweight devices, deployed in physical attachment to a 90 cm. or 150 cm. anti-aircraft searchlight, the earlier ones being used in large numbers, with service in the North African and Italian theaters. Total production amounted to 8,796 sets. Remarkably, they were designed to operate from the searchlight electrical supply system, a 22 kW 80 volt DC Lister four cylinder diesel generator with an auxiliary 2000 Hz alternator. Although they seemed to see relatively little use for instructional purposes after 1950, AACSTI had two such radars, a No. 2 Mk. 6 unit and a centimeter wavelength No. 2 Mk. 9. The accompanying drawing shows one of several variants on the searchlight-mounted Yagi theme, all of which looked remarkably spiky.

NO. 3 RADARS

This large group of APF's was the HAA. successor to the original GL series. All our No. 3's were magnetron based, with 10 cm. wavelength, or 3000 MHz frequency. Entwined in their development was the strong desire and need for auto-follow capability. While AACSTI's No. 3 Mk. 2's did not have this, the No. 3 Mk. 5 (U.S.A. SCR-584) and the later British No. 3 Mk. 7 did, and it was put to good use in the 1944-1945 battle over south-eastern England against the German V-1, the *"flying bomb"* or *"doodlebug"*.

No. 3 Mk. 1 was designed and built in Canada by REL, Research Enterprises Ltd. A single large trailer had two relatively small dish antennas mounted at the front of the rotatable cabin, the magnetron tube being located at the dish, with a too-exposed high voltage connection to the pulsed high voltage supply down in the

cabin. As with other No. 3 sets, a right-angle sighting telescope was mounted with the antennas, and reputed had it that at least one ATS operator took an unscheduled header from the dish area after making inadvertent contact with high voltage as she tried to take a sight on a calibration target.

The No. 3 Mk. 1 or 3C had an unenviable reputation at AACSTI, where the general belief was that it had been declared obsolescent on arrival in the UK. Certainly it was felt at much higher levels that co-operation between Canadian authorities and the British War Office and Ministry of Supply was regrettably absent during the 3C's design. Even more certainly, in 1950, while the 3A (SCR-584) and 3B (No. 3 Mk. 2) were in constant use for class instruction, the 3C's were only being cannibalised for their rich store of high quality components. Nonetheless, it appears that they were used to fill the gap left in British home defence anti-aircraft forces when more suitable equipment was needed in the European theater and late deliveries dictated that it be taken from home defence units. Ambitious specifications for the 3C included automatic locking onto and following of targets, and while these aims were achieved in the 3A for bearing and elevation, the 3B in the same period was very manual. Some of the 3C solutions were of the brute force variety. Elevation and azimuth servo systems used DC motors driven by FG-27A mercury thyratrons, which we gave a poor reputation for reliability in such field applications. On the other hand, the magnetron supply, series pulse modulated by Heintz & Kaufman 304H triode tubes, was similar in concept to that in the very successful 3A or SCR-584.

No. 3 Mk. 2 The No. 3 Mk. 2 started life amid confusing labels

as type “3A” and “3B” experimental sets in 1941, pre-production sets becoming available disappointingly slowly through 1942. Final deliveries of a total of 876 units were made through April 1945 when production ceased.

Initial specifications were for a 3000 MHz equipment, with an eventual pulse power output of 100 kW. Of massive construction, built like a tank by British Thomson-Houston or maybe Metropolitan-Vickers (both have been named), it weighed in at close to ten tons with a steel fabricated cabin on a big four wheeled chassis (Fig. 3). Like the 3C, the No. 3 Mk 2, informally and usually known as the 3B in 1950, had twin dish antennas 4 ft. in diameter sitting side by side atop the elegant rounded bow which formed the front end of the cabin. Unlike the 3C, the cabin was fixed, and the antennas, connected

through a very solid silver plated brass coaxial feeder system maybe about 2 inches in i.d., were located on a massive rotatable turret some 4 ft. in diameter and 6 ft. or more high, which, from inside the cabin, could be readily accessed by a mechanic on all sides.

All the turret compartments were lockable, interlocked and locked for safety, using Castell Keys more familiar to electrical power engineers. The inside regions contained the transmitter, and its power supply, and the front end of the receiver, which was designed by EMI and A.D.R.D.E. (Air Defence Research and Development Establishment). The turret was connected by slip-rings and was rotated by manually operated selsyn drives, the antennas being similarly raised and lowered together in elevation angle. A motor rotated the receive antenna on

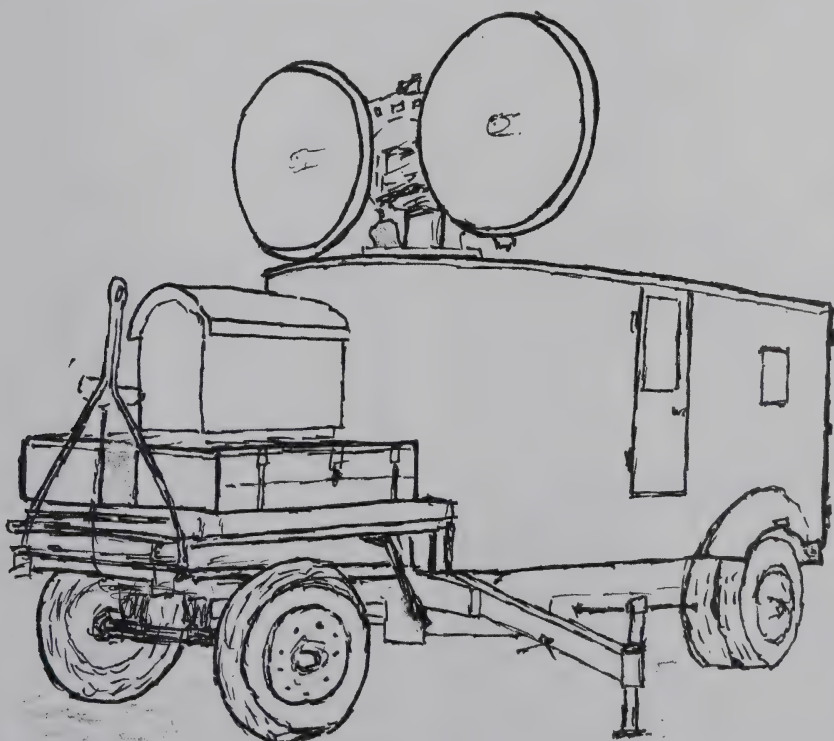


Fig. 3. No. 3 Mk 2 or GL3B. Clearly shows up as the massive equipment it really was.

its axis at a few hundred r.p.m., providing a split beam, although apparently some models had a nutating drive to maintain constant signal polarization.

The receiver front end local oscillator was a cavity tuned CV67 reflex klystron, and the 3000 MHz mixer was a crystal similar to a 1N21. In 1950 we thought of both as quite conventional. These point-contact silicon crystal mixers came from the stores labeled with either red or yellow dots and wrapped in protective lead foil to protect them from stray R.F. fields, and there was much folk-lore attached to their selection.

Near the back, crossways in the trailer, was a large solid rack some four feet high. Three feet deep and six feet wide, it contained the receiver IF stages, CRT and other lower voltage power supplies, time base circuitry and such further necessities as the CRTs for range, bearing and elevation. A passageway on the left as one faced forward, provided turret access.

On the rear of the rack were the two 230 volt 50 Hz selsyns and their polished steel hand-wheels, the small range hand-wheel and its potentiometer circuit, and lastly, seats for the three operators, and the rear access door, also on the left. The range hand-wheel controlled a strobe visible on all three CRTs, while by the use of the bearing and elevation selsyns, no servos, no power amplification at all, the ATS operators strong-armed the turret motions, and it all worked very well. Magslips relayed the bearing, elevation and range data to the predictor. During 1944 auto-following enhancements had been designed but production problems repeatedly deferred this project until the Army canceled its final request for 450 modification kits in June 1945.

Hardly anything ever went wrong, and when it did it was a nightmare, if anything more than tube swapping was needed. While my personal recollection focuses on tubes with the then British standard 4 volt heaters, possibly large five and seven pin types such as the AC/VP2 and AC/4PEN, surely the Mazda-Octal based SP41 must have had a place in the IF amplifier. Rack electronics were on very massive solid steel chassis, about 10 or 12 Gauge, all interconnected by heavy cable forms terminated on blocks with neat preformed wire loops firmly secured by row after row of 4 BA (roughly 6-32) binding posts and nuts. Removal of one of these chassis called for several hours work with nutdrivers and screwdrivers, secure in the knowledge that once the chassis was removed our only credible check-out was a visual inspection. Nonetheless, the 3B had a good reputation for reliability and apparently continued in use in some services, mainly meteorological, through to the 1970s.

Moving a 3B was a matter of some delicacy, as it was mandated that at any speed more than 5 m.p.h. either a man must walk alongside, ready to operate the large brake handle that protruded on the left near the front wheels, or that a properly equipped towing vehicle, normally an AEC "Mata-dor", be used. Sound advice is not always followed, and at least one well remembered journey from London area REME workshops to Lydd was far more exciting than AA Command could have appreciated.

No. 3 Mk. 3 & 4 The No. 3 Mark 3 or "Baby Maggie", a light-weight derivative of the 200 MHz S.L.C.'s seems to have been unknown at AACSTI, although 176 were made and it saw service in

North Africa and also in the USSR. The No. 3 Mk. 4, originally known as the A.F.1, was the almost hand-built predecessor of the No. 3 Mk. 7. Fifty were originally ordered, a number reduced as war was ending, to twenty four. Eventually two were supplied in August 1945 as prototypes, with further deliveries in early 1946. We understood that many or most had been later converted to No. 3 Mk. 7's.

No. 3 Mk. 5 The major American contribution to AA Command efforts, the SCR-584, known in Britain as the GL3A or later as the No. 3 Mk. 5, arrived at the right time as a workable solution to the severe problems of production and delivery encountered in provision of British equipment, where Royal Air Force and Royal Navy competition for priorities was extraordinarily intense.

While the 3A, 3B and 3C shared some of the same brute force solutions, the 3A had one enormous asset. It worked well. The unit was built in a four wheeled trailer, with a single large roof-level paraboloid antenna some 8 or 10 ft. in diameter (Fig. 4). This, with its mountings and drive systems, was mounted on four screwjacks which could retract it, for transport, into the space between the receiver and transmitter racks. The series tube pulse modulator and the 10 kV DC power supply for the transmitter, on left and right respectively, were located toward the front of the trailer, with a passage between them, and with interlocked doors for access. The receiver and time bases and other such circuitry were in a rack across the rear of the trailer, which also provided the CRT displays and operator

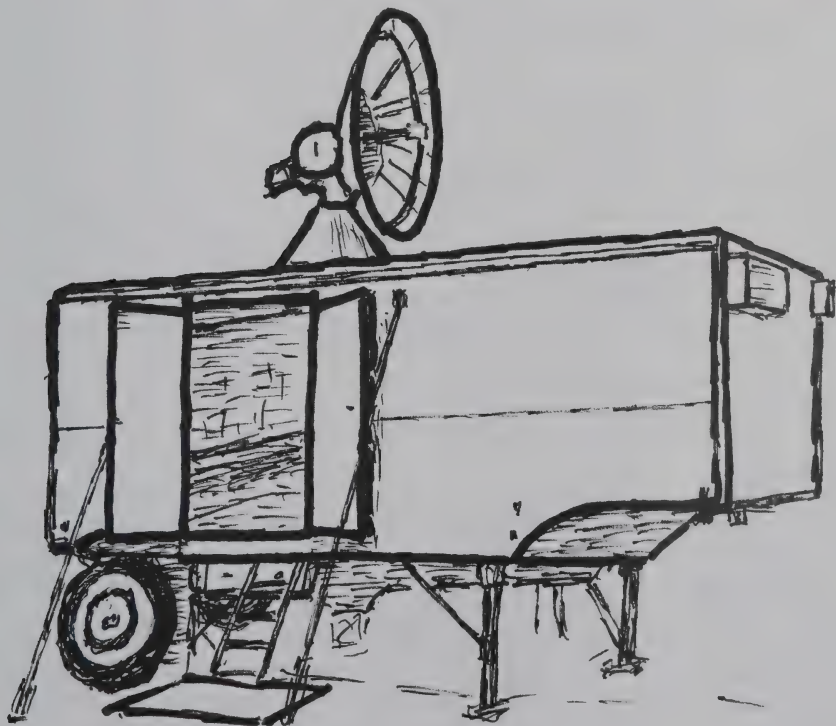


Fig. 4. No. 3 Mk 5, GL3A or SCR-584 The USA's valued contribution to the stable.

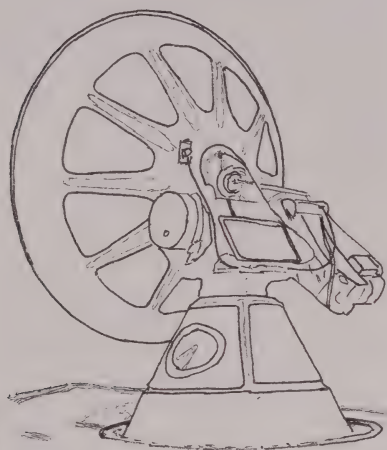


Fig. 5. No. 3 Mk 5 The massive antenna and its mounting.

positions. Auto-following had been implemented, though only for bearing and elevation. The main access door was in the middle of the right-hand side, as one faced forward.

Unique features for us were the electric trailer brakes, again calling for an AEC "Matador" towing vehicle or other proper equipment, and the big skid-mounted Caterpillar diesel generator. This was provided with a small rope-started gasoline pony engine, sometimes notably reluctant to co-operate in starting the diesel in the damp cold wintry weather which frequently rolled into Lydd right off the English Channel, no more than two miles distant.

No. 3 Mk. 6 This Canadian APF fire control radar was not represented at AACSTI in 1950-1.

No. 3 Mk. 7 The largest population at Lydd was of this relatively small trailer mounted radar with a fairly large, maybe 6 ft. diameter retractable paraboloid antenna. It offered a more highly developed auto-follow system than the SCR-584, which however retained a

range advantage due to its larger antenna. Cited accuracy was 8 min. of arc and 35 yds. in range.

The Mk. 7 was said to be designed to fit into the cargo space of a *Hamilcar* glider. These gliders, towed two, or possibly even three at a time, behind a C46 aircraft, then known in England as a *Dakota* and later familiar as a Douglas DC-3, were flown by soldier members of the British army's Glider Pilot Regiment, and were to contain everything needed for a field force in the invasion of Europe, including radar support for anti-aircraft protection. With such restricted dimensions, a man of ordinary height could not stand upright in the trailer's limited working space, and the compact mass of electronics needed powerful air-conditioning to maintain workable internal temperatures, both for it and for the operators.

The working parts were in a rack along the left hand side wall of the trailer, with the transmitter and modulator towards the rear, the CRT display desk and range potentiometer circuits in the middle, and the time base and signal handling chassis toward the front. The six or eight roll-out electronic chassis were interconnected by unhandy early coaxial plugs and sockets and multipin Jones plugs, and as ours were often pulled in and out of the rack for tuition purposes, resultant cable flexing ensured frequent failure.

The pulse modulator, a Blumlein delay line unit, was more difficult of access, and it was known for a mechanic to slide the modulator outward, remove the transmitter, and enter the rack headfirst and downwards to access rear connections. A space at the rear with even lower headroom contained the bearing gear box for the antenna with its servo drive motor and a

belt driven feed-back tachometer generator.

An exciting fault introduced for students was removal or reversal of that drive belt, the resultant positive feedback setting the heavy antenna into fairly violent to and fro oscillation at about 1 – 2 Hz. If the student did not kill the power supply rapidly, it was said that the trailer would lift off its stabilizer jacks. For transportation, the antenna was retracted somewhat downward into that space, the demountable solid air-spaced coaxial line to the main electronics rack being first removed.

Receiver IF circuits at 45 MHz used many EF50 tubes, silver or red, with their nine pin glass bases, while other circuits, often ubiquitous long-tailed pair comparators,

used the EF55, a taller variant with higher dissipation, and therefore always black. Other tubes were octal based 6SN7s, and all instructors owned at least one example which although faulty, had intact heaters. The tell-tale heater glow was a valued tracer in fault-finding instruction. In the same area were the bearing and elevation drive servo amplifiers, the final power stage of which was provided by rotary amplidyne sets (derivatives of older Ward-Leonard types) which, together with the air-conditioning compressor, were hung outside on the trailer's front wall. In the same area, motor generators took the 230 volt 50 Hz incoming supply from a diesel engine generator and provided 80 volt 2000 Hz to the electronics supplies in the

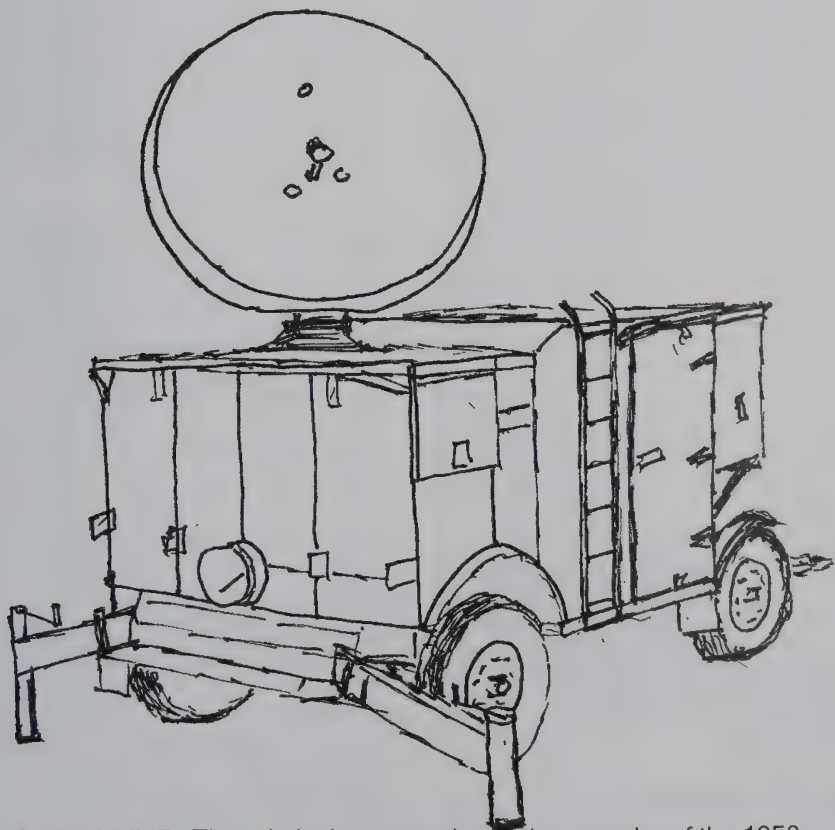


Fig. 6. No. 3 Mk 7. The relatively cramped work-horse radar of the 1950s.

cabin.

The display desk contained an 8 or 10 inch PPI tube, and a much smaller A-scan tube. Behind it was the range potentiometer, a complex device with a vast multiplicity of small screws which could be adjusted to distort a metal track which by cam action would bring the range system to a good linearity against a crystal oscillator producing blips at 250 yard intervals. This was both tedious and difficult. The unit of distance, as usual, was the kiloyard, and the No. 3 Mk. 7 could be effective up to a range of 30 kiloyards. With quite a good PPI scan, it was designed to be reasonably serviceable not just as an APF or gun layer, but also as an early warning radar, with the antenna set at a low elevation angle.

The large and heavy door was opposite the equipment rack, and alongside it was a ladder to the roof and the antenna. On the antenna mount was the standard right-angle spotting telescope, looking out through the paraboloid and along the radar beam. It was very satisfying with a well tuned-up Mk. 7, the only Lydd radar which had a fully effective autotrack in range as well as bearing and elevation, to lock on to an unsuspecting civilian plane, then climb up the ladder and follow it across the sky in the telescope. Equally memorable was the set of effects following any untoward event which tripped the main power breaker; total darkness in the windowless cabin as the lights all went out, as the air conditioner fell silent, and all that remained was the whine of the now unloaded motor generator and amplidynes as they coasted down to a standstill while the operator fumbled for the door handle.

NO. 4 RADARS

A No. 4 radar was an early

warning (E.W.) unit, or zone position indicator (Z.P.I.), sometimes known as a "putter-on", designed to scan 360 degrees of sky continuously for incoming enemy aircraft. It was typically deployed with a No. 3 set, a predictor, and an anti-aircraft gun to complete the basics of a fully equipped heavy anti-aircraft site.

No. 4 Mk. 1, 2, 3 & 4 Of these radars, none of which were present at AACSTI in 1950, the Mks. 1, 2 & 3 all operated in the 175 – 215 MHz region, the No. 4 Mk. 1 being Canadian and associated with the No. 3 Mk. 1 (3C), while the No. 4 Mk. 4 was a 600 MHz unit.

No. 4 Mk. 5 The author admits to a special feeling for this remarkable radar, having had in his charge what was possibly then the last operable surviving example for a large part of 1950 and 1951. It only added to this feeling to find out many years later that the No. 4 Mk. 5 was known, even in the War Office official history, as "*Gorgonzola*" because of its very large cheese antenna!

An ungainly and extraordinarily effective assembly of disparate pieces of equipment, it was assembled in a real hurry by the Radar Research and Development Establishment (RRDE) for 21 Army Group's use. The War Office Director of Radar had requested urgent provision of a centimetric unit which could serve in France very soon after D Day as an aid to tactical control of ground air defences and also possibly for area early warning (Figs. 7,8).

R.R.D.E. Workshop staff and REME personnel hand assembled twenty-two Mk. 5's, the first fifteen of which went into action without trouble immediately after landing. As Royal Navy and Royal Air Force counterparts were largely lost or damaged getting ashore,

these crash-produced units were for some time the only means available for providing warning of approaching hostile aircraft. Their performance was sufficiently recognized that a special commendation was sent from on high to the army staff who had at very short notice, obtained, found, commandeered, bought or made the component units and assembled this most unusual conglomeration of available parts.

The basis was the versatile trailer originally designed for the Radar No. 1 Mk. 2 (the GL2) and the entire cabin therefore rotated on its four wheeled chassis using the same bicycle pedal system. However, there were no further similarities. The transmitter placed against one side wall was a Royal Navy type NT-277 10 cm. magnetron unit, then believed to be Lydd's highest powered unit at 500 kW peak. The output was coupled into a fabricated vertical waveguide which went up to a horn

that tapered out into the mouth of a large cheese reflector mounted on the roof.

The cheese was maybe some 15 ft. by 2 ft. in aperture and some 4 ft. deep. A mechanic could easily have crawled into it. The receiver, which had a small A-scan tube, may have been a Royal Air Force type, but the PPI display unit was certainly of that origin. It was mounted with the tube face vertical, in front of an operator who sat on a bicycle saddle manipulating the pedal-like handles on a pedestal in front of him.

The PPI tube was of the then very large dimension of maybe 16 or 18 inches diameter, and CRT scan arrangements were noteworthy. A set of magnetic scan coils, connected by slip-rings, mechanically rotated around the neck of the tube as the cabin turned on the chassis, being connected to the central pivot of the cabin by a length of speedometer cable and a helical gear. Given the high perfor-



Fig. 7. No. 4 Mk 5. Does not show the I.F.F. antennas which, in service, were above the cheese.

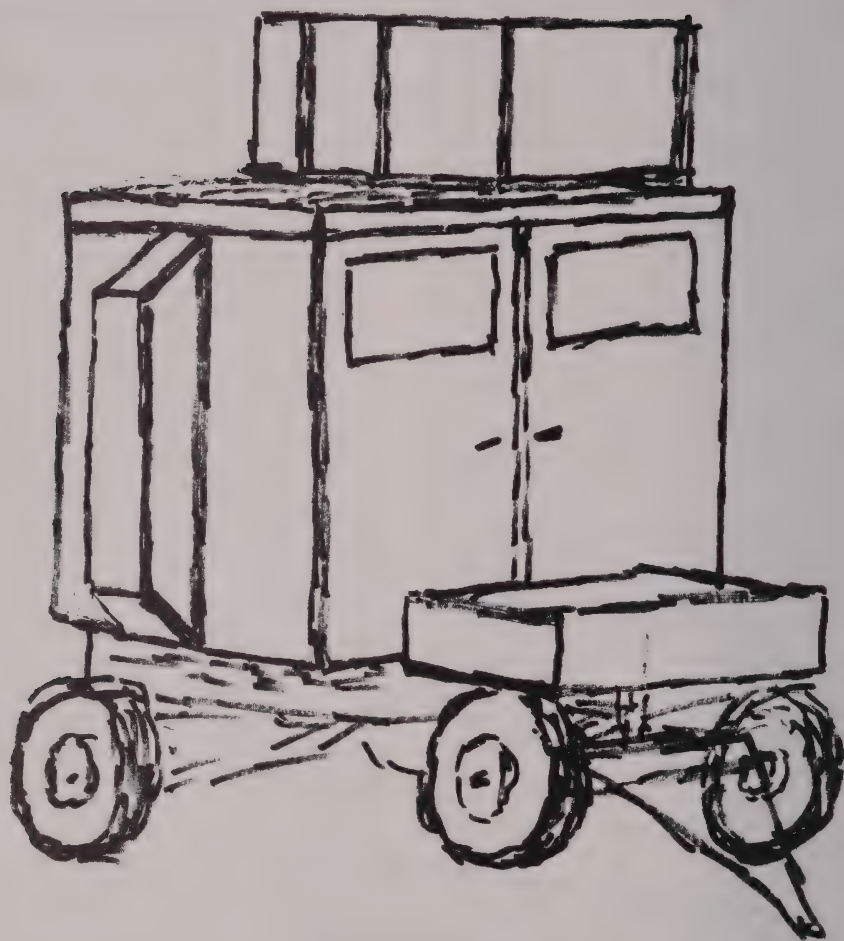


Fig. 8. No. 4 Mk 5. This particular piece of equipment was photographed at Lydd.

mance of this exotic combination, an operator could only too easily forget himself and concentrate on watching the PPI scan, with a rapid onset of the quasi-sea-sickness noted earlier. Again, continuous rotation for a 360 degree scan seems most unlikely, and would certainly have called for excellent "sea-legs".

If heavy equipment is mounted on a turntable, balance is essential, and as a result the disposition of the various units inside the cabin was not conducive to easy access. Entering the rear door, right rear

if the cabin was parked, a narrow alleyway led past the receiver rack to the seat and its handles, facing the PPI unit, which was alongside the receiver, with the transmitter behind it. At the far end of the cabin was a large motor generator with 230 volt 50 Hz power input and 180 volts at 500 Hz output, the unusual voltage and frequency being due to the Navy and Air Force origins. In the farthest corner was a manual starter, and the old fashioned split-phase capacitor start motor took forever to come up to speed, the operator waiting more

or usually less patiently for the moment when the starter handle could be swung over from “start” to “run”. Change over too early and the diesel outside would protest loudly at the virtual short-circuit thus imposed, and it was necessary to start over from the beginning.

The No. 4 Mk. 5 had a generous performance. One target appeared regularly at the appropriate range and bearing on the PPI tube, and was firmly believed to be the Eiffel Tower in Paris.

The two drawings, of two different examples of the No. 4 Mk 5, show the large cheese antenna and waveguide feed. The under-pinnings of the chassis structure are little more than guesswork, as the original photographs showed

nothing much more than deep shadows!

4 Mk. 6 The “Zippy” or Microwave Zone Position Indicator (MZPI) was one very successful design from Research Enterprises Limited in Canada, so presumably the communication failures which had led to the 3C’s unfortunate situation had been sorted out. The trailer was a very rectangular and solid looking box, on a four wheeled chassis as usual, with a large waveguide slot type of broad-side array antenna resembling no less than an overgrown ironing board, usually in steady rotation at about 15 r.p.m., on the top. Open slots would have allowed weather into the waveguides, but “Zippy tape” had been invented to seal

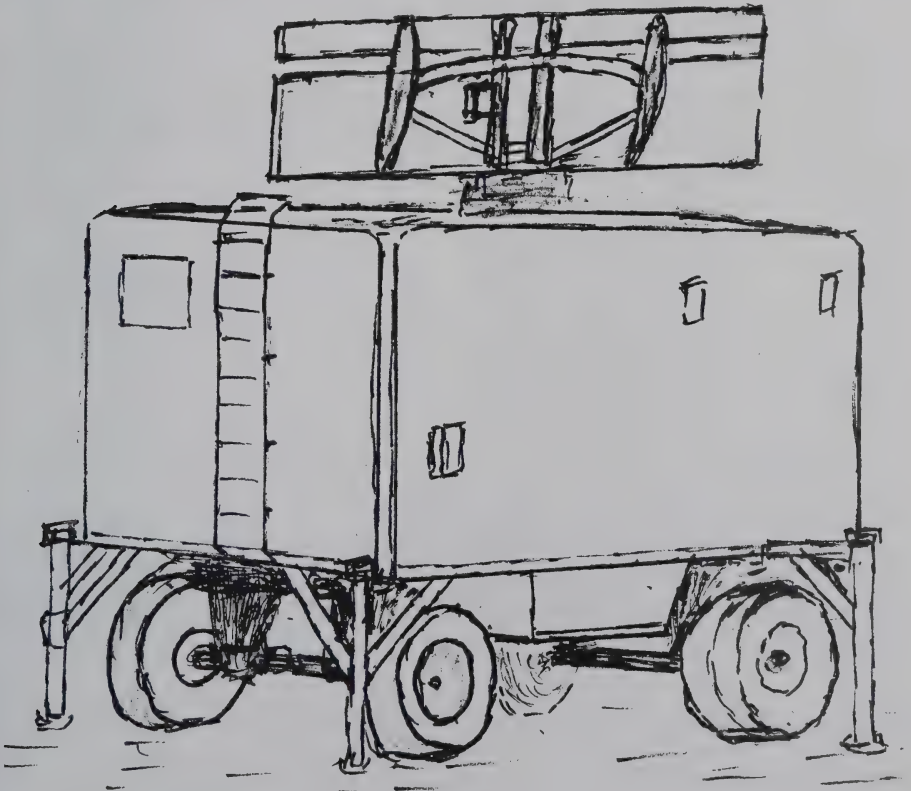


Fig. 9. No. 4 Mk 6. A very plain and effective box on wheels. Rear view of the slot array antenna.



Fig. 10. Two No. 3 Mk 5s are located on Lydd's omnipresent and bleak shingle landscape.

them. Naturally it was pressed into unauthorized use for every imaginable and unimaginable use in that pre-duct-tape era.

The stability question in design and operation of crystal oscillators for calibration work was noted above for the No. 1 Mk. 2, and the No. 4 Mk. 6 had a pragmatic approach to the matter. Whereas in the No. 1 set the use of an army boot was mentioned, the Zippy was slightly more elegant. A large contactor, with no connections except to the actuating coil, was located in, on or by the oscillator chassis. Known as the "panel-bashing relay" its only function was to administer to the crystal that sharp mechanical shock so necessary for reliability, at the appropriate point in the start-up routine.

The Zippy was powered from a Hobart skid-mounted generator, and like the No. 3 Mk. 7, was provided with an air-conditioning unit. The compressor was always filled with oil for the journey from Canada, and as a large label or two pointed out, drainage before start-up was essential. Naturally, on at least one occasion this did not occur, and the result was a very messy mechanical disaster.

Other Equipment The British designed radars were all

powered from two-wheeled trailer-mounted generators, mostly three-cylinder Lister diesel driven 17 kVA units providing 230 volts 50 Hz., with a quite effective electro-mechanical Niphan regulator system. Starting was manual, with a large hand crank, and decompressor cams which could be released from the cranking position. One-man starting was possible, but called for excellent timing with the decompressor bar, and in our usual cool weather was not too often successful. Searchlights were powered by four-cylinder Listers, 80 volts 22 kW DC with 2000 Hz auxiliary AC power. The SCR-584s or No. 3 Mk. 5s had skid-mounted American Caterpillar diesels, while the Canadian No. 4 Mk. 6 Zippies used Hobart units. Finally, while IFF or identification-friend-or-foe systems, mostly in the 150 - 200 MHz region, had been fitted to many anti-aircraft radars by 1946, Lydd's equipment showed only a few minor traces of this development.

SOURCES

A principal source has been the official history of the British Army in 1939-1945, one section of which, "ARMY RADAR", was compiled by Brigadier A.P. Sayer and issued by the War Office in 1950 as a *restricted document*. My personal recollections of service at AACSTI owed much to AQMS Carpenter and his knowledge of World War Two days. Several internet sites are useful, one which has a comprehensive list of relevant equipment being www.anti-aircraft.co.uk. Another very wide-ranging source is www.radarpages.co.uk. Much information on the contribution of ATS or WRAC personnel is from www.atsremembered.org.uk. A great deal of useful and interesting correspondence took place



Fig. 11. Overall view of Lydd Radar Wing in 1951, with a few of the radars then on site. From the left, three No. 3 Mk 2's are together, and then an Elsie, probably a No. 2 Mk 9, and a No. 3 Mk 7. Next, against the building, a No. 3 Mk 7 and another No. 3 Mk 7 partially obscured by a radar which may be a No. 1 Mk 2. Finally, against the building, a No. 3 Mk 2, the receiver rack of which had been removed and installed inside the building for instructional purposes.

with Peter Watts, also formerly of AACSTI, and with Mike Dean, who had initiated the Historic Radar Archive at www.smecc.org/radar_history_groups.htm Very many thanks are due to all.

ILLUSTRATIONS

Good reproducible pictures of British military anti-aircraft radars of 1940-1950 are somewhat scarce, and the line drawings accompanying this article have been originated from a variety of sources, including the author's own 1950s photographs, which were usually no better.

ABOUT THE AUTHOR

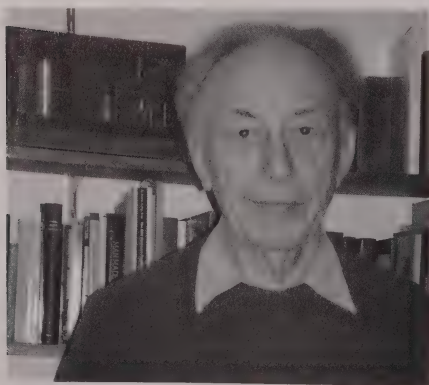
Crawford MacKeand, WA3ZKZ, was born in 1931 in York, England, and also educated in that ancient city. He served 1949 - 1951 as a radar instructor in the Royal Electrical and Mechanical Engineers, and in 1954 graduated from the University of Manchester in electrical engineering. Seven years in the telephone transmission field, latterly as a telephone cable system construction engineer in the UK and in Venezuela, have been followed by thirty years in chemical process plant instrumentation and control, and in chemical plant process safety, and almost twenty years of as busy, or busier, retire-



Fig. 12. A view of a corner of the parade ground, in approximately the opposite direction from the previous photograph. On the left two No. 4 Mk 6's, (with a water tower behind them) then two No. 3 Mk 7's and what might be a No. 1 Mk 2. Next a 17 kVA Lister diesel generator on its trailer, and the No. 4 Mk 5 in the background. Finally a No. 3 Mk 7 with its heavy canvas antenna protection hood in place.

ment. He has authored a number of articles, several in the amateur radio field, and has published two books. "Sparks and Flames" is a history of gas engine ignition, while "The Friendly Ionosphere" is an engineer's view of radio signal propagation. Interest in the latter was supported by his 1990s publication of SNAPmax, a propagation and noise prediction program. He has been interested in radio since his teen years, was first active in amateur radio in 1950, and has been licensed as G4ARR, WA-2ZVX, WA3ZKZ and as VP8CMY.

Member and sometime president of the Morris Radio Club in New Jersey, the Delaware Amateur Radio Club and the First State Amateur Radio Club, his ham activity has been almost entirely in digital modes, from RTTY in 1972 through AMTOR and Pactor to PSK31 and Hellschreiber in recent years. In other interests, he lectures at the University of Delaware's Academy of Life-Long Learning on very various subjects, from "The English Monarchy" to "The History of Railroads", is a director and at times a project manager for the Delaware Nature Society, and even finds a little time for family matters too.



Crawford MacKeand

Mirror Screw Television: 25 Years of Experience

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ABSTRACT

The mirror screw, a scanner for producing television pictures, was patented in 1928. From the very beginning, it was said that television pictures needed to be larger, brighter and sharper than possible with earlier systems, all of which were available with the mirror screw. One of its problems appeared to be due to a "Not Invented Here" syndrome. For most suppliers of television materials, they themselves had patented whatever they were selling. Only one company, TEKADE of Germany, tried to develop the mirror screw commercially. After five or six years they abandoned the project. By that time, full electronic television was under development. In this article, the author's 25-year effort to replicate and demonstrate mirror screw televisions is described in detail.

The history of television began in the 1880's, predating both wireless and the telephone. It was an offshoot of early facsimile, or the sending of images over wires. There were more than a dozen schemes for sending visual images by electricity that appeared from 1877 to 1884.¹ These schemes were not usually demonstrated as models, but were paper plans. Still they established principles that led to further developments in the coming decades. The most influential scheme was patented by Paul Nipkow in Berlin in 1884. Mechanical problems related to rapid scanning and synchronization were neatly solved by a spinning aperture disk. Apparently no apparatus was constructed nor did Nipkow attempt to exploit his invention. It was, however, the basis of much experimentation over the next 45 years.

George Shiers has identified 785 patents and proposals on mechanical systems and devices related to television from 1878 to 1930.² Prominent among these were more than 30 patents related to television filed from 1919 to 1925 by Charles Francis Jenkins, a motion picture pioneer from Chicago. In the summer of 1925 he sent moving outline images of a model windmill and silhouette figures from motion picture film by radio over six miles in Washington, DC. John Logie Baird from Scotland filed 10 patents in the years 1923 to 1925. Baird adopted Nipkow's aperture disk and, through many modifications, refined it and kept it as his favorite scanner until 1929.

The year 1928 was prominent in the development of television, with more than 130 patent applications.¹ The Nipkow disk and others derived from it appeared in more than 50 patents. An entirely new scanner, the mirror screw, was patented by Delamere B. Gardner of Los Angeles. Significant corporate players were active in the field by 1930. Baird Companies held 69 patents, Bell Labs 63, General Electric 26, Jenkins Companies 31, RCA 25, Telefunken 31, and Westinghouse 30. If any of these companies had

decided to adopt the mirror screw it could have had a significant future, but apparently they did not.

Whenever I would mention mechanical television, folks tended to have developed a mental image of some sort of disk, rotating at high speed and somehow providing a very small picture. That is a good guess. Yes, prominent in early mechanical television was a rotating disk called a "Nipkow Disk" patented in Germany in 1884.³ In the years following, there would be many attempts to show overall picture improvements using a modified Nipkow disk or various mirrored systems. However, it would be more than 40 years before a recognizable image appeared on the screen.

As developments approached closer to a practical form of television, it became apparent that the light efficiency was being severely limited by the small scanning holes.

This was the case at both the camera and the receiver, because both were operating with a Nipkow disk. By increasing the diameter of the disk, using larger scanning holes or even lenses, overall improvements were possible. John Logie Baird once was faced with a situation where he was almost killed by a scanning disk some eight feet in diameter with 30 lenses the size of bowling balls. At some point while bringing this disk up to speed, one lens broke away causing the entire wheel to go out of balance. It vibrated very strongly, expelling the remaining lenses around the room. John had taken cover under a massive desk and escaped injury.

MIRROR DRUM

An early improvement over the Nipkow disk was the mirror drum (see Fig. 1) The inventor was Jean Lazare Weiller.⁴ For its size, it was the most light efficient mechanical scanner. In its original form, there

were as many mirrors as there were lines in the picture, with each mirror tilted at a different angle relative to the axis of the drum. As the drum rotated, each mirror caused a line to be scanned above or below the previous one. Beyond 60 lines with mirrors of reasonable size, the drum became excessively large. The mirrors were also very difficult to adjust.

As photocell sensitivity and light sources improved, scanning-hole size or lens diameter could be reduced. This allowed the disk diameter to be reduced. Reducing the disk size resulted in a more compact scanning assembly. As an example, Western Television of Chicago produced a televisor with a 17-inch aperture disk and a flat-plate neon lamp. It provided a 45-line picture, 1-1/8 by 1-1/2 inches. The following year (1931) they developed a new 45-line model with an 8-inch diameter lens disk, providing a much larger and brighter picture, measuring 4 by 3-7/8 inches. The improvement was due to the use of both the lens disk and a more efficient light source, a crater-arc neon lamp. This new model included an 8-tube receiver, which the previous model did not, and the complete receiver occupied only about half the table space as before. From this time on, there was a major effort by those



Fig. 1. Mirror drum constructed by the author.

involved in the mechanical television business to develop small, low cost scanners that would produce large bright pictures with improved resolution.

Meanwhile there was constant pressure to increase the number of lines in the image. However this tended to increase the size of the scanning assembly. Commercial television started with 24-line pictures, mostly because of the bandwidth limitations of transmitters operating in or just above the broadcast band. As the transmissions were allowed to move up in frequency, more lines could be added to the image, improving image resolution. With pictures up to 60 lines, scanning disks with holes, lenses or mirrors could provide acceptable pictures with disks of reasonable size. Beyond that (and the next step was 120 lines), the holes, lenses or mirrors became too small or the disk too large and the requirement for manufacturing precision too great for scanning disks to see further use in receivers. By 1932, the Nipkow disk had had its day. This was also the end of the "low definition" era of television. With 60 lines (or fewer), television images were limited to close-ups of actors or scenes with large recognizable objects. At 120 lines and more, television took on movie-like qualities, with "long shots" as well as close-ups, where scenery added to the impact of the actors. This was the beginning of high-definition television (HDTV).

THE MIRROR SCREW

The typical mirror screw consisted of a stack of identical long, thin, narrow mirrors made of aluminum or stainless steel (Fig. 2). Each had one of its long edges polished to a mirror finish. The stack of mirrors was set on a central shaft and positioned in the

form of a spiral staircase. The total number of mirrors was the same as the number of lines in the picture. Each mirror was displaced in angle from the mirrors above and below and the angles were all equal. In a 120-line mirror, each mirror would be accurately positioned 3 degrees from the previous one, so that the 120 mirrors formed one complete spiral. The thickness of each mirror would be the same as the picture-line thickness and the mirror length the same as the picture width. Therefore, the height of the mirror stack would be the picture height. Other than the polished edges, the entire exposed surfaces of the mirror slats were painted with a non-reflecting dull black paint. The mirror screw always operated in total darkness with the signal-modulated light source pointed at the screw, but located near the viewers.

When the mirror screw rotated at picture frequency (say, 20 frames per second) the stack of mirrors appeared to run together and became a single mirror, as tall as the stack and as wide as the individual mirrors. A narrow line of light with its width the same as the mirror-slat thickness and as tall as the stack of mirrors fell on the screw from a location beside the viewers. The intensity of this light was modulated by the picture signal. As this light fell on the topmost mirror, the mir-



Fig. 2. A 32-line mirror screw.

ror reflected a square spot of light toward the viewers. This spot was formed by the width of the light source and the height of the mirror slat reflecting it. Because the mirror was rotating, the spot appeared to move across the mirror screw. This represented one line scan and three degrees of rotation. Very quickly, the mirror below moved into position, received the light source and performed its line scan. And so on with all the other mirrors in turn until one revolution of the screw was complete. This comprised one complete picture and the mirror screw was then ready to begin scanning the next picture.

The mirror screw was a major improvement over previous scanning methods. The advantages of the mirror screw were its light efficiency, compactness, picture size equal to its height and width, capability of high resolution (for its time) and a wide viewing angle. (Fig. 3) A typical mirror screw might be approximately five inches high and six inches wide. One 180-line mirror screw manufactured in Germany measured 9 in. by 12 in. For a Nipkow disk to show a 180-line, 9 in. by 12 in. picture, it would have to have been over 53 feet in diameter. On the other hand, a 12 inch Nipkow disk would have produced a 180-line picture less than $\frac{1}{4}$ inches square.

MY DIRECT EXPERIENCE

My story began in Canandigua, New York, when in 1985 during the annual AWA Conference, I managed to acquire two original 120 line mirror screws. It was late in the afternoon when two young men came by, carrying a cardboard box. They placed the box on the ground before me and asked if I might be interested in buying what they had.

Upon seeing what was there, I

had an idea of what they might be, but wasn't certain because there were no marks, identifying labels or tags anywhere on the two pieces. It seemed that they had been cleaning out someone's garage and were told they could keep the "stuff" or throw it all in a dumpster. These two mirror screws were part of that salvage. After a few minutes of discussion, we did come to an agreement on price. I found myself now owning two items that I didn't expect to buy and wasn't sure yet, if it was such a good idea to buy them since I knew so little about them.

After returning home, I soon learned that they both were in fact mirror screws. I also found that although they appeared to be similar in size and construction, one did weigh 15 pounds and the other only 7 pounds. The mirrors on the heavier one were made of stainless steel and looked to be in excellent shape. However, on the other they were aluminum, all of which had a light film of surface corrosion. At this particular time, I had no thought of or how I might



Fig. 3. The first mirror screw receiver made by the author.

use them in the future. Like many collectors before me, once you get something new and different in your hands, one takes a much greater interest in whatever it is. And that is how it was for me. I immediately was on the lookout for any books, publications or persons

that could provide me with new nuggets of information about mirror screws. I also made a simple patent search and found one by D. B. Gardner, Patent#1753697, filed 9/17/1928 (Fig. 4) This appears to be the earliest patent related to mirror screws.⁵

April 8, 1930.

D. B. GARDNER

1,753,697

REFLECTING AND SCANNING APPARATUS

Filed Sept. 17, 1928

Fig. 1.

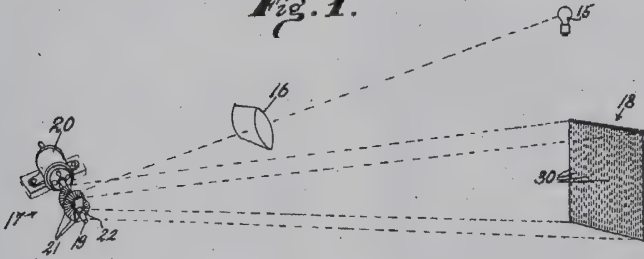


Fig. 2.

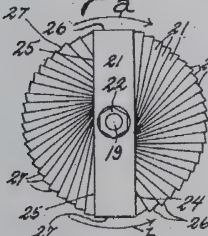


Fig. 3.

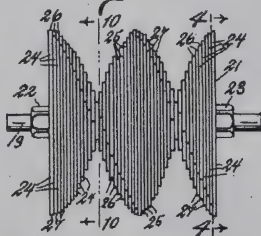


Fig. 4. Fig. 5.

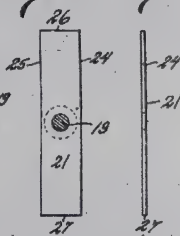


Fig. 6.

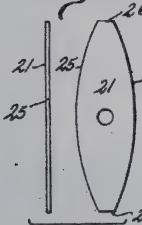


Fig. 7.

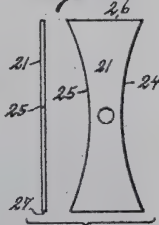


Fig. 8.

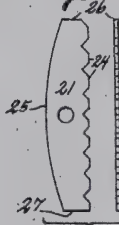


Fig. 9.

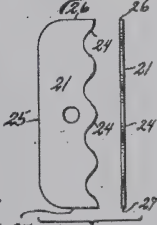
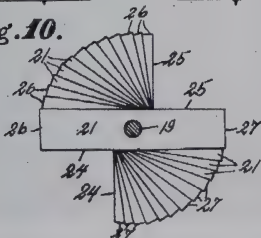


Fig. 10.



Inventor.
Delamere B. Gardner.
by
Lockwood & Lockwood,
His Attorneys.

Fig. 4. Mirror screw patent filed by D.B. Gardner on September 17, 1928.

Mirror Screw Television

About a month or so later, I came across a photo of a German mirror screw kit receiver. (Fig. 5) Even the mirror screw came as a kit and had to be assembled, along with the rest of the set. Another photo of still another German set was one that I found most interesting, but a closer look suggested that it was actually a drawing. (Fig. 6) However, on that day, I decided that this one would be my guide for the first one or more receivers that I might later decide to build.

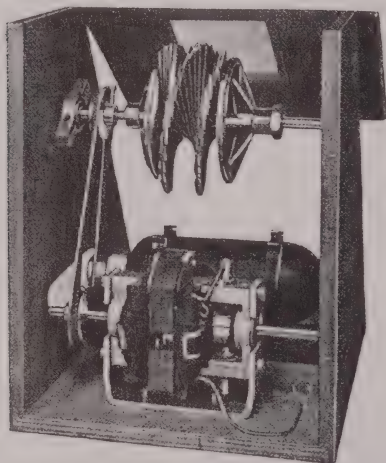


Fig. 5. German mirror screw kit receiver.

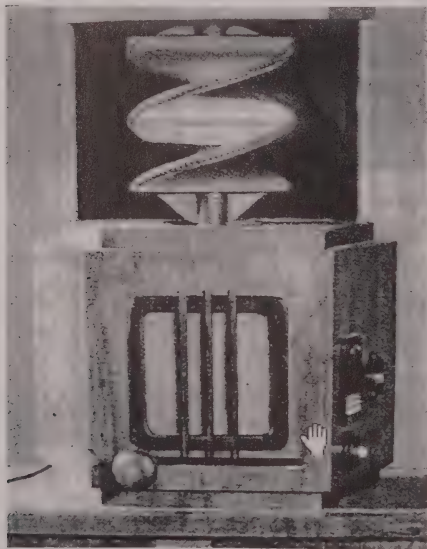


Fig. 6. Mirror screw set drawing.

The two mirror screws that I have are approximately the same size. They measured 6.25 inches in diameter and 5 to 6 inches long or tall. On the one, there are 120 line-forming mirrors made of stainless steel. The mirrors are very bright and the same as new. On the other, also with 120 mirrors, they are aluminum and do have surface corrosion, but I felt it needed to actually be tried out, to see how good or how bad it might be.

About a year or so later, I decided to build a mirror screw, from scratch, with materials that I had on hand. I decided to use $\frac{1}{4}$ " plywood as the basic material. For the reflecting edges of the mirrors, I would use $\frac{3}{16}$ " acrylic mirror stock. I built electrically heated fixtures that would allow mirror stock to be accurately fastened to the edge of the wooden "mirrors". High wattage resistors supplied the heat for curing the epoxy. (FIG. 7) I found out later that this mirror screw turned to be out to be one of the largest mirror screws ever made. It was the 32 line, 16" diameter mirror screw pictured here. (Fig. 8) The motor was set up so that its body could be rotated separately for synchronizing. The screw itself was supported on two ball bearing races. (Fig. 9).

After about another two years had passed, I managed to acquire only one reference that proved worthwhile. It was an English textbook from George Newnes Limited, London written in 1935 that covered early British Radio.⁶

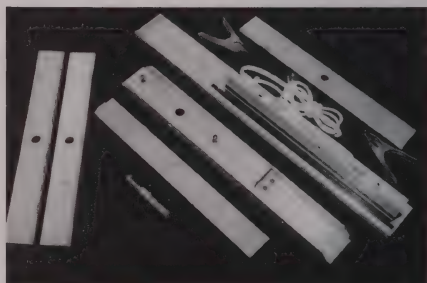


Fig. 7. Special tooling for building mirrors for the 16" mirror screw..

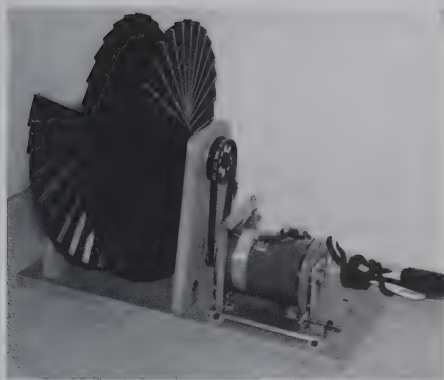


Fig. 8. Thirty-two line, 16" mirror screw.

(Television Today, in two Volumes) It had two chapters that pertained to mirror screw technology. This made for very interesting reading, except that almost nothing useful was mentioned about the special light sources required for mirror screws.

About this time, I would soon start building two receiver cabinets for the two screws I already had. Upon closer inspection, I determined that the mirror screw with the aluminum mirrors was defective beyond use. The corrosion on the polished surfaces was completely preventing any light reflection by this screw. In spite of this setback, I continued work on both cabinets.

The other mirror screw was constructed with stainless steel mirrors and in spite the many years



Fig. 9. Mirror screw showing a picture of Felix the Cat.

since its manufacture, estimated to be 1932, those mirrors were still in excellent condition.⁷ The receiver that was built for the stainless mirror screw turned out very well. It produced a very good picture with 120 lines of resolution. The image size was about five inches by six inches. I also developed and built a 120 line Nipkow camera, so the AWA members could see the set in operation at the 1997 conference, seeing an original "Felix the Cat" rotating on a turntable. The members seemed very excited about what they saw and the only complaint that I heard about the picture, had to do with its orange color.

Almost all of the early mechanical television receivers used neon lamps with their characteristic orange color. The main reason for using neon lamps, was their ability to respond to the wide frequency range of the picture signals, while at the same time producing a reasonable level of picture brightness. In my early television demonstrations, along with a new amplifier of my own design, I chose to use Light Emitting Diodes (LEDs) as my light source. In that period, the range of colors available was very limited but did include orange, which happened to closely simulate the color of neon lamps. Now in more recent times, the range of colors has grown to be very broad, including the primaries, the complementaries and now even white is available in a range of half dozen or so color temperatures.

For my year 2000 demonstrations and later, I have replaced the existing orange LEDs with the white high brightness variety and increased their number as well. I since have further developed a new video amplifier offering increased current gain and now includes DC restoration. The result was a much-

improved overall dynamic range of the video system. The next time I demonstrated the receiver, the improvement was very noticeable to all those that had seen it before the changes were made.

For my input signals, I always have included a Darryl Hock television format converter (Aurora Video Systems Inc., Sterling Heights, Michigan, 48314.) with a DVD movie input, plus sound. This converter changes our present television signal format, (525/60) to the one necessary for the 32/60/120-line mirror screws to operate properly. It also provides RGB color signals making color mirror screw movies possible. The films I have selected generally have many close-ups showing just one or two main players at a time in each scene. This hookup does not improve the image resolution provided by the mirror screw, but it does offer a means to see first hand the improvement in image quality both in size and brightness, as compared to the best that was available with the Nipkow disc.

MIRROR SCREW CONSTRUCTION

The recent mirror screw demonstrations have had a lasting effect on me as well. The effect was to cause me to feel that I could and maybe should build the entire screw myself. I have the training, I have the machine shop tools and by this time, I have some first hand experience with mirror screws too. So I felt there would be very little risk. I felt certain I could do this and began by contacting a local machine shop, equipped with the usual machines, including large shears and experience in working with thin stainless steel sheets. I was able to speak with a machine operator himself, to show him my

drawing that explains the reason for flatness on the parts sheared from a 48-inch wide stainless steel sheet. Based on what I had already learned up to now, I decided to start by building two prototype screws, just to get a feel for what would be involved. I asked this company to cut for me at least 150 of the stainless steel pieces that would become the mirrors. Once set up, they had actually cut 180 pieces, more than enough material for the mirrors of both a 48 line and a 32 line mirror screw. (Fig. 10)

It was obvious to me that there was a lot of work to be done before I could finish these two prototype screws. This seemed to be a good time for me to determine what part of the remaining work I would be doing and what parts would I have others do. I concluded the workflow might look something like this:

Start >{invent/copy}>{improve/correct}>{simplify/abandon}> go back, start again.

I began with my copy of the invention patent papers of the mirror screw by Delamere B. Gardner, (see Fig. 4 above). I found that Mr. Gardner had a total of seven patents and that his first patent was the only one that would effect what I had in mind.

My list of steps began like this:

Each mirror would have an accurate dimensioned 1/2 inch diameter center hole. Because one

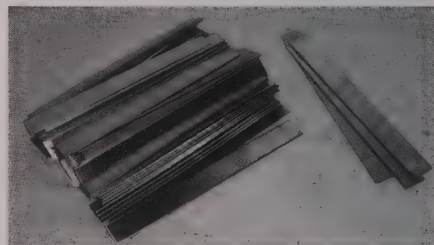


Fig. 10. Material cut for two mirror screws.

is working with stainless steel, this becomes a two step operation. Drill slightly undersize ($15/32$ ") and ream these holes using a $.500$ " reamer. This work can be done in a drill press. (Fig. 11) A special support fixture is used to hold the mirror while the drilling and reaming goes on.



Fig. 11. Set-up for drilling the center hole in each mirror.

Now with the center hole sized and in place, it was a good time to assure that the mirror lengths were correct and that both ends of every mirror were properly radiused. A photo of the special clamping tool that was built so it could be held in a 3 jaw chuck and allow the lathe work to be properly done, is shown in Fig. 12.

The mirror surfaces of a mirror screw must all be ground and then polished to a mirror finish as a complete set. Therefore a holding fixture is required that will hold the correct edges of the set of mirrors together, to allow the grinding of the complete set of mirrors simultaneously. (Fig. 13) In a later step,

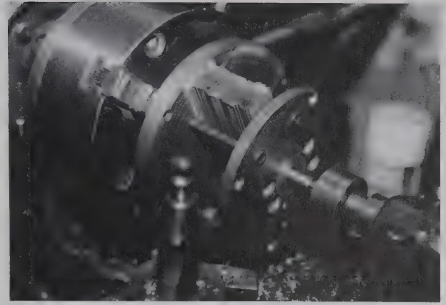


Fig. 12. Special tool for lathe to cut a radius on mirror ends.

the polishing will be done in the same manner.

The grinding theoretically could be done by hand, but as found out later, only if you start out very young and manage to live a long time. (Fig. 14) As shown here, the

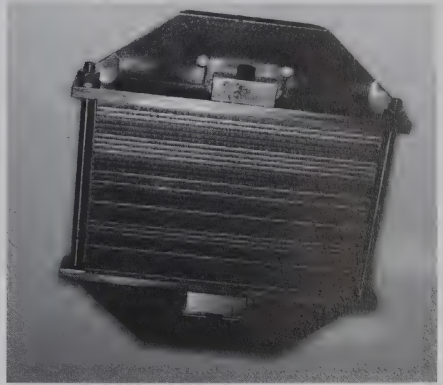


Fig. 13. Mirrors in a holding fixture.

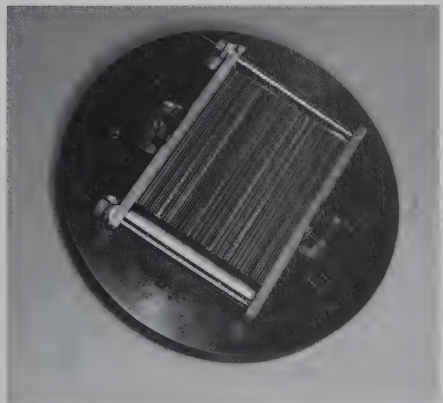


Fig. 14. Holding fixture mounted on a faceplate.

holding fixture is mounted on a faceplate in a lathe, where light cuts are taken across the surface, about .050 inches total, or until the surface is smooth. Even lighter cuts were taken at the highest spindle speeds, to provide as smooth a surface as possible. (Fig. 15) The faceplate was then removed with the holding fixture still attached.

The plan was to set up a small table (Fig. 16) with corner clamps, to support standard 9" by 11" sheets of emery papers of various grits. Then begin with a # 80 grit emery, the holding fixture, was simply rubbed across the emery surface with suitable hand pressure as necessary applied.

The emery paper was to be renewed on occasion whenever



Fig. 15. Surface smoothed with light cuts.

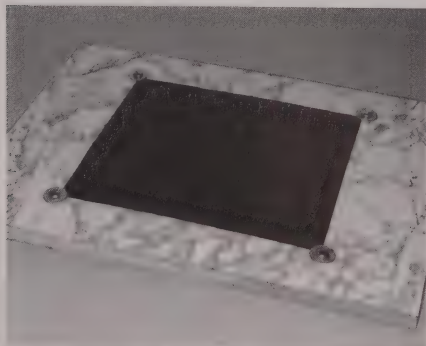


Fig. 16. Table arrangement to hold emery paper.

the progress seemed to be going too slowly. When no further improvement was seen, the emery was to be changed to a # 400 grit and continued on. Just as before, occasionally, renew the # 400 grit emery until no further progress was seen and then change to a #1200 grit emery. Again, just as before, continued grinding with the # 1200 grit emery and renewing as necessary, until no further progress was noted.

And that was the plan...but with the first sheet of # 80 grit emery still clamped down, after one full day of grinding, or approximately 10 hours, I could see the process was going much too slowly. At this rate it would take many months before one would be using the buffing wheel. So it became necessary to come up with some better method, to motorize the initial grinding step, up to the point where buffing could begin. I called my idea "The Inverted Surface Grinder". Many machine shops have a tool that is commonly known as a surface grinder. For some shops, it is often one of their most used machine tools. This machine usually has a flat table to which the work piece is clamped, where it can be moved back and forth. On some surface grinders, the table is also able to move from side to side. The grinding element is a motorized grinding wheel held above the table and adjustable in height.

Since I had already purchased most of the 9" X 11" emery paper I would need, I planned to use it for the Inverted Surface Grinder as well. I also had a surplus garage door lifting mechanism from some years back and an electrical motor speed control from the same period.

I have a radial arm saw with a fairly large work table and I planned from the beginning that

the Inverted Surface Grinder would fit and operate on that saw table. Most of the construction material was going to be wood, or metal where necessary.

The photo (Fig. 17) shows the emery paper clamped in place on the grinder table. There are two clamps on each end of the emery. The faceplate has the mirrors clamped in their support fixture, with the mirror surface down, (Fig. 18) and they are turned over in contact with the emery paper. A connecting rod is then placed on the crank pin (Fig. 19) on the left and the extended shaft in the center of the faceplate shows some of the driving mechanism. The electric motor assembly contains its own internal (Fig. 20) gear reduction and drives a small chain sprocket, coupled with a chain to a

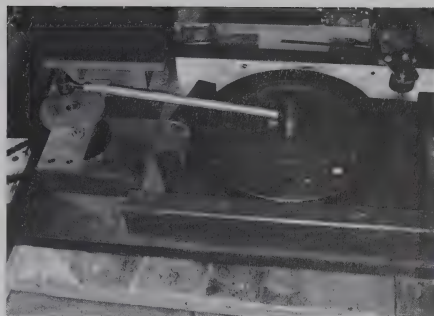


Fig. 19. Connecting rod placed on the crank pin.

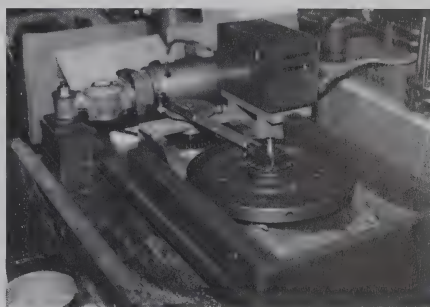


Fig. 20. Electric motor assembly.



Fig. 17. Emery paper clamped in place on the grinder table.



Fig. 18. Mirror surface in contact with the emery paper.

slightly larger sprocket, supported on double ball bearings. On the same shaft, there is a crank pin above, giving a stroke of almost three inches.

The motor speed controller is a commercial unit able to give a range of one stroke in two seconds, up to two strokes per second. It also contains a resettable time counter for minutes and hours for logging purposes. See an overall view of the grinder on the radial arm saw table in the photo. (Fig. 21)

The faceplate assembly, with the holding fixture for the mirrors attached, including a set of mirrors, weighs approximately 15 pounds. In addition, shown in the photo is a 25-pound lead weight for a total 40 pounds. In addition, another smaller lead weight of 15 pounds was available and could be added above the 25-pound weight for a maximum total of 55 pounds.



Fig. 21. Overall view of the grinder on the radial arm saw table.

Using my log book as a reference, these are some of the important points during the first grinding/polishing operation for the 32 line mirror screw with 25 pounds added weight.

The set of mirrors supported in the holding fixture on the faceplate was first faced in a lathe and approximately .01" was removed. The faceplate was taken from the lathe and installed in the grinding machine, using an 80 grit emery with the mirrors assembly in contact with the emery and the speed set for about one stroke per second. The emery was renewed every 1 to 2 hours, for a total of about 14 hours. Then changed to # 400 grit emery and renewed every hour for a total of 6 hours. Then replaced the emery with a #1000 grit and renewed every hour for a total of 6 hours.

Total motorized grinding time was about 26 hours. The next operation would be the buffing. The holding fixture assembly with all of the mirrors still intact was then removed from the faceplate so the buffing operation could begin.

At this point, the polishing begins using motorized buffing wheels with a black buffing compound. The entire mirror surface needs to have the same level of polish before it can be called finished. A device that can measure

the reflectance of the mirrors can be very handy at this time. I managed to build one using the component parts of a General Electric exposure meter. (Fig. 22)

It contains 4 AA batteries, two bright white LEDs and the exposure meter. The meter is located in such a manner, that the only way that the reflected light from the LEDs can reach the photo-cell of the meter is by first reflecting from an external surface (that would be the mirror surfaces) and then back into the body of the meter. A small mirror held against the meter serves as a calibration point and relative reading that one can at least try to approach in the polishing process



Fig. 22. Home built reflectance meter.

It is usually best to do the polishing overall gradually, rather than working in one area, then another and again another. The entire surface needs to appear to be a good single mirror. Continue to apply the black compound to the buffing wheel a number of times, until no further improvement is noted, then change to a different clean buffing wheel with a compound for brighter finishes, usually green in color. Again, do

as was done before, now with a green compound. When far enough along, you should expect to see results similar to the one shown here. (Fig. 23)

The intent was to use cast aluminum end plates, because every mirror screw I had ever seen in the past was made using those plates. It seemed a given, that it was just what one does. Besides that, it also gives the mirror screw that desirable "old look". On top of that, the wood casting pattern looked easy enough to make. So, I didn't hesitate to get started on it right away.



Fig. 23. Results with a completed mirror.

Two of the cast aluminum end plates would be required for each mirror screw. Wood patterns are required when having sand castings made in a foundry. Most foundries prefer to work with what are known as "match plates" which can provide multiple castings per pour. An individual pattern is referred to as a "loose pattern" and generally, only the smaller foundries will accept these when you place an order for castings. I began to build the wood casting pattern (Fig. 24) shown here along with four resultant castings. In the photo, the machine work on two of

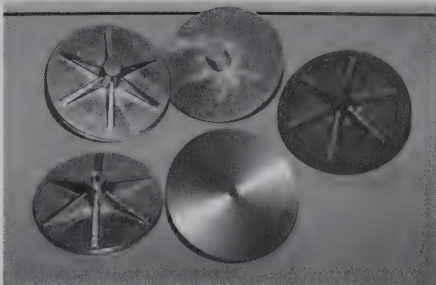


Fig. 24. Wood casting pattern with four resultant castings.

the castings is done. Arrangements were made to have the castings poured in aluminum, at a local

brass/aluminum foundry. I would then machine the castings and static balance them on a small static balancing stand as shown here. (Fig. 25) The stand contains a small level so it can be set level prior to tests. During the balancing tests, heavy locations in cast-

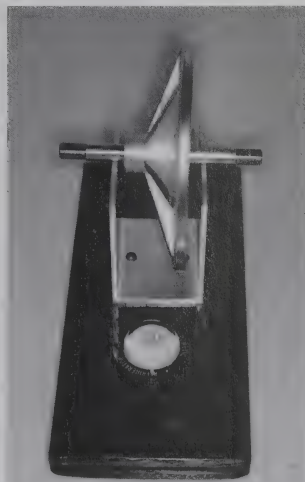


Fig. 25. Small static balance.

ings can be lightened by drilling and tapping the outer edge of the body to accept an 8 X 32 screw, 1/2 inch deep. Various lengths of aluminum or brass 8 X 32 screw stock, can be fitted to correct any of the unbalance. Drilling one or more shallow holes in the main body of the casting will also work.

Of the two prototype mirror screws, the 32-line screw was completed first. With the experience gained, the plan was to use greater care in adjusting the mirror settings of the 48-line screw. Because a need already exists for this screw, it could be put into use just as soon as it was ready. It was thought that using an accurate metal template, set for the common angle between the mirrors, might be enough to produce a usable mirror screw.

To some, it might appear that this could be an easy way to reduce the time required to complete this task. Why not just install all of the mirrors on the axle, then the washer and the nut, but not so tight as to prevent one's fingers from moving individual mirrors as need be, using the template if and when you need to. Then tighten the nut very carefully, being careful to not move any of the mirrors on the axle in the process. This process of adjustment sounds simple enough, but I can not recommend it. I bring it up, because to many, it would seem to be rather intuitive. Especially if you are only planning on doing one set of mirrors. The fact is that setting the mirrors correctly will most likely to be the most critical step in the process of building the mirror screw. There is a need to look for a better way than this.

I did take greater care in setting the mirrors using a template with a fine adjustment on the angle. The nature of using this method is that it seems to start out all right, but after 30% of the work is done,

you can see, it is not going to work out. You have two choices. Destroy what you have done and start over or make an adjustment and continue. I chose the latter. At 60% complete, I found I was now going out the other way and I was faced with the same questions as before. So I made another, this time a tiny adjustment and finished. The result was "pretty good" or good enough. In this case, it was not worth doing over. I will be able to use it as it is.

I thought about balancing the mirror screw with the sand-cast aluminum end plates. It is well known that cast aluminum quite often has internal voids that would affect the balance of any rotating parts. When operating at normal speed, vibration of the mirror screw mirrors themselves can cause a "blurring" of the smaller details in the image. I later came to the conclusion that the entire mirror screw might need to be in dynamic balance! This would become my goal for later.

But for right now, I had arranged with a local machine shop, the Sauer Machine Co. for a visit as scheduled, to talk about ways that they might help me build the stainless steel mirrors for mirror screws. I had a few drawings, two of my finished mirrors and some pictures. I spent an hour with them, during which we had a very good discussion. I learned about their ways to machine stainless steels with zero stresses on the parts being machined, during and after the work is done. I also learned of their ability to meet certain dimensional requirements, which I found to be impressive. When I left them, I agreed to work up a drawing for them to consider and price, and I would get back with them after they've had a chance to see exactly what I wanted.

The mirror screw has a steel axle, on which the mirrors are actually secured. Two versions of the axle are shown in this drawing (Fig. 26). The difference between the two is in the shaft collar. It might be either a threaded screw-on type, with an internal $\frac{1}{2} \times 20$ thread or collar that is pinned in place as shown in the lower illustration. When the work of buffing is finished, the mirrors need to be carefully removed from the holding fixture and placed on the axle in the same order, one at a time just as they were in the holding fixture originally. The mirrors must be very accurately positioned to the correct angles on the axle and then locked into place with cyanoacrylate cement, (Super Glue). Some sort of dividing device able to position the mirrors accurately must be used.

The mirrors will be installed on the axle starting at the bottom and working up. The spur gear in the set up fixture must be at least 5 inches in diameter or as much as 12 inches in diameter and the gear must have the same number of teeth or a multiple of the total

number of mirrors on the screw. If using a multiple, consider marking the gear teeth appropriately with a small drill or adhesive tape. Larger gears will offer greater accuracy in adjustment. As each mirror is brought into position, starting with the first, the choice of washers selected can be made so the speed nut along with the washers in place are able to control and set the pressure on the mirror in play. Try to keep the number of washers in any one setting to less than three.

When mirror #2 is brought into position with the gear setting changed accordingly and the washer arrangement changed if necessary, the next mirror can be adjusted and set to place the light spots on the charts, slightly above the previous spots. As more mirrors are added, the spots on the chart will continue to elevate, and the light source can be raised to offset that. One of the conditions one needs to be aware of when adjusting these mirrors, is that the pressure applied by the speed nut to the stack of mirrors will affect the mirrors position. Ideally, the pressure would be the same with

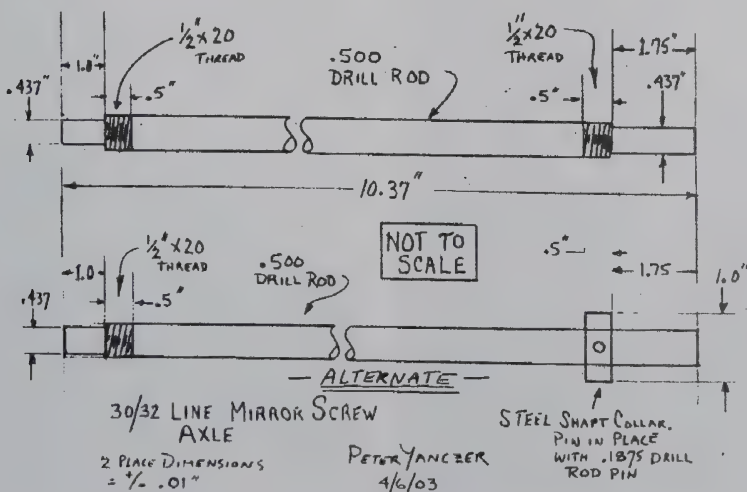


Fig. 26. Two mirror screw axles.

one mirror as it is adjusted or with all of them as the last mirror is adjusted. Setting the mirrors correctly will most likely be the most critical step in the process of building the mirror screw.

Some years ago, I had built a tool which was actually a special kind of drill press, able to accurately locate and drill the holes for Nipkow scanning disks. Based on the knowledge that gears in general were very precisely made, this tool used the teeth of a large spur gear to determine the exact angular position of each hole to be drilled. With a mirror screw, in a similar way, each mirror must be precisely located. (Fig. 27) Here is a picture of the basic set up for accurately positioning these mirrors. There is a light source that projects a narrow vertical line of light that falls onto the mirrors of the mirror screw and reflects from there onto a vertical paper chart, located some distance away. This setup is able to provide an adequate degree of accuracy necessary for adjustment of the mirrors.

I got started by doing the following: The end of the axle where the collar is located goes into the gear, centered properly and tight, using set screws or what ever method you may have. The bottom side of the gear must be in some sort of a bearing, giving freedom for the axle to rotate only. A minimum

of free vertical motion is allowed. The gear must have some sort of an associated spring loaded stop, able to mesh without lost motion with any tooth in the gear.

Some years earlier, I had designed and built a 16mm movie projector to television converter.⁸ This machine was similar to one used in 1928, by C. F. Jenkins when he began using their company owned short-wave radio station (3XX), operating on 6420 KC, to transmit 48 line Radio Shadow Movies. Based on mailed in responses, the station determined they had an audience of about 20,000 looking in. For my own use, I had an operating companion 48-line Nipkow disk receiver, providing a 1" by 1" picture. A mirror screw could provide an optical upgrade to a 3" by 4" picture and it was my intent to build the 48-line mirror screw for the television converter. Since I have recently completed the 48-line mirror screw, I will be able to finish that upgrade.

I needed to build a special tool, consisting of five or so thick washers, as mentioned earlier. (Fig. 28) The setup washers are 1" diameter aluminum, each with a center hole about 9/16" in diameter, so they can readily pass over the 1/2" diameter axle. The lengths are 2", 1", 1/2", 1/4" and 1/8". None of these dimensions are critical. In addition, a "speed nut" will be most helpful. It is a 1/2" x 20 steel hex nut with two 2.5" lengths of

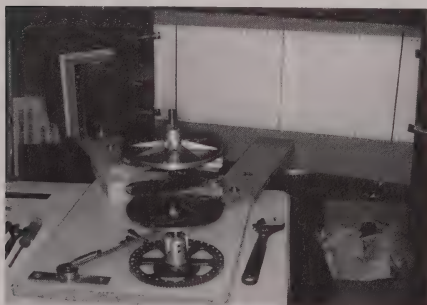


Fig. 27. Set up for positioning mirrors.

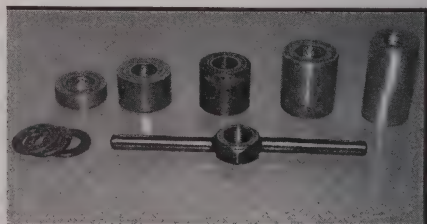


Fig. 28. Tool for tightening the washer arrangement.

$\frac{1}{4}$ " drill rod brazed onto the nut, 180 degrees apart. This tool should always be available and especially when there is slack in the washer arrangement, which suggests a washer rearrangement might be in order.

The mirrors will be adjusted one at a time, in a fixture which includes the aforementioned large spur gear, with the mirror screw axle firmly held at the center of the gear. Off to one side is a light source projecting a bright narrow vertical line on and parallel to the axle. Notice the light source must be able to be raised or lowered without causing a change in its angular position.

A few words about the original light source. (Fig. 29) This light source internally contained three 12 volt automotive tail light bulbs, a transformer for 120 volts with a 10 volt / 3 ampere, secondary plus a switch and line cord. The bulbs were in a vertical line on 3-inch centers, with the bulb sockets turned so that the filaments were also in a vertical line.

I later worked out a much more successful design. This final design was built around a laser pointer. (Fig. 30) The light from this laser first passes through a small, .5" x .5" cylindrical lens, which converts its small intense red spot of light, to

an intense, yet narrow, vertical, red line of light. This form of light was well suited for the work at hand. As mirrors are added and adjusted one at a time to the assembly, the light source is raised as necessary to keep the reflected light on the chart. The structure of the base is designed to allow the lamp to be raised or lowered by the operator with no change to its angular position. The base of the assembly contains two AA batteries and a control switch for the lamp.

The procedure is to remove the speed nut and place the first mirror on the axle, exactly the as it came off of the holding fixture. The first mirror will therefore be on the axle against the end plate, which is next to the collar, all of which are now on the axle. Center the mirror

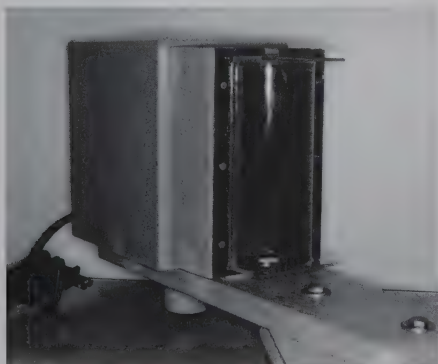


Fig. 29. The original light source.



Fig. 30. More successful light source.

where it is in contact with the end-plate. Select the set up washers to fit the span between the mirror #1 and the speed nut, trying to use less than three washers in each set up. Use the nut to remove any slack, changing the washer arrangement as necessary. Now with zero slack, note the size and location of the reflected light spot. Using the speed nut, move the light spot one spot width or length, from where it was. Place two drops of glue on the rear edge, opposite the mirrored edge. In ten seconds, the speed nut and washers can be removed, the second mirror placed on the axle, rotate the gear assembly one tooth clockwise or the multiple number of teeth, for the second position. Select the minimum number of appropriate thick washers to cover the span from mirror #2 and the location of the threads for the $\frac{1}{2}$ " x 20 speed nut. Install the speed nut and washers, adjust the tension as before, position mirror #2 and apply the glue as before and prepare for mirror #3.

Once I had a mirror or mirrors in the proper position, it or they will be held there by the friction and the clamping action of washers and other mirrors, above and below, in the stack of mirrors. Here are some points to keep in mind and allow for. You will need to carefully remove the nut each time you add another a mirror onto the stack, as you fill the axle with mirrors one at a time and adjusting the thick washers accordingly, in sort of a parallel path with the mirrors. Try to use no more than two washers at a time.

The idea is to set the pressure on the mirrors using the nut, while establishing the correct mirror positions. With experience, one can better do that by "getting a feel" from the handles on the speed nut. The handles that have been

added could help develop this skill. You want the pressure to be or feel about the same, each time you add a mirror to the stack or change washers. Every time a mirror is added and adjusted, use two dabs of cyanoacrylate (SuperGlue) for 10 seconds, along the edge opposite the mirror, before releasing the pressure and installing another mirror on the stack. In addition, each time you add a mirror, you will position the mirror, according to what the chart shows, with the correct pressure applied. Then apply two dabs of glue and in 10 seconds release the pressure. Any spillage of glue onto the mirrored surface can be removed, using a soft cloth with acetone.

The picture (Fig. 31) shows me setting up for the mirror position tests, following the adjustment cycle. Note the adjustable light source. It uses the internal working parts from a red laser pointer. The mirror screw in this photo is the first of four 32-line mirror screws made up using the cast aluminum end plates.

Another mirror alignment setup shown here has a very large, 12-inch diameter gear with 120 teeth. This setup was used for setting the mirrors of on all of the 60 line mirror screws that I have made. The double page chart appears in



Fig. 31. Author Yanczer setting up for mirror position tests.

the photo to be very small, but it is about 6 feet away compared to the location of the screw. The chart is actually two 8" by 11" sheets. (Fig. 32)

Based on an experience I had many years ago, I felt I could build a machine that would enable me to dynamically balance my mirror screws. I was presently planning to build some larger screws with an increased number of lines, that would therefore operate at a higher RPM, making balance even more important and I already owned a dual channel oscilloscope. I needed a strong support for the various parts of the balance machine so I chose an 18-inch length of 2 inch by 6-inch wide steel channel. This became my base. It in turn would be bolted or clamped to a vertical milling machine table, whenever the balance machine would be in use. By this time I had already put together a series of sketches that defined the various parts of this machine. Little by little, it came together. And as they say, it worked right off the bat. Shown here is the smaller 60-line mirror installed and in working order. (Fig. 33)

Later on, my mirror screws were getting larger in diameter as well as in length. I expected this and had built into my set up equipment a large range of adjustment.

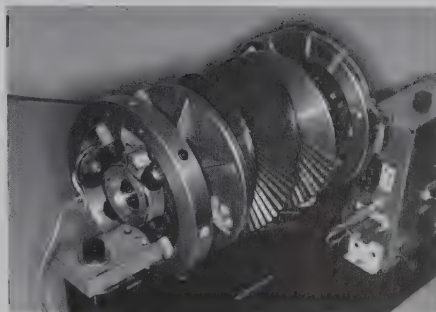


Fig. 33. Sixty line mirror installed.

Some mirror screws also operated at a higher RPM, which necessitated a change to a more powerful driving motor.

Four of the larger 60-line mirror screws were built. This photo shows the dynamic balance machine bolted to the vertical milling machine table. The mere mass of the milling machine greatly enhanced the capabilities of the balance machine. (Fig. 34)

After the four larger 60-line mirror screws, I decided to return to the smaller size in both 32-lines as before and now a 60-line also. I would also in this next group, incorporate all I had learned in building the first ten mirror screws. Both of these mirror screws will provide images measuring about three by four inches. They are light enough in weight that they can often be supported on just the motor bearings. Since there are no longer any

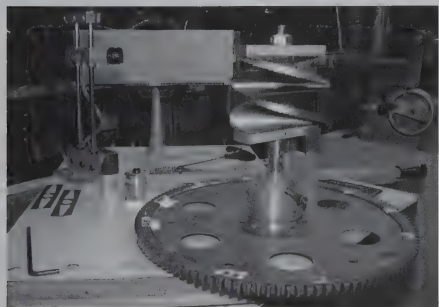


Fig. 32. Alignment setup for setting the mirrors on 60 line mirror screws.

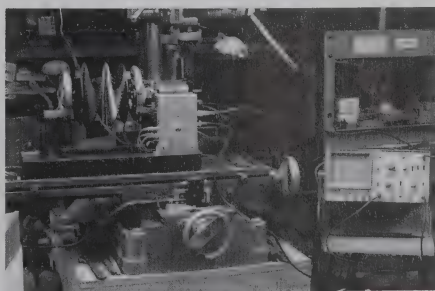


Fig. 34. Dynamic balance machine bolted to the vertical milling table.

Mirror Screw Television

castings used in their construction, these mirror screws are inherently balanced. The smaller 60-line screw is pictured here. (Fig. 35)

It appears there is a total lack of any representative forms of actual television receivers using mirror screw scanners. In a few instances where a photo turned has up as in this case, it was found in a German engineering text book written in 1932.⁹ A friend of mine who lives in Germany brought it to my attention. (Fig. 36)

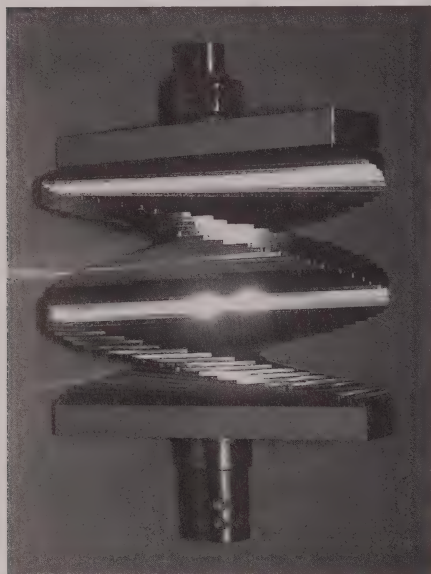


Fig. 35. The smaller 60-line mirror screw.

It was unusual in that it was built in two pieces, one of which included a mirror screw. I felt I could build a similar set and proceeded to do just that. I entered it in a contest at the AWA annual Conference in 2008.

The set was in operation, showing a motion picture with sound. (Fig. 37)

The work described here was done over a period of about 25 years, I have actually built about 35 mirror screws and of that num-



Fig. 36. German mirror screw receiver from 1932.

ber, about a dozen have gone into some sort of cabinet, along with the amplifiers, power supplies, light sources, and whatever else was necessary to form a working demonstrable unit

THE FATE OF THE MIRROR SCREW

In spite of all the years, especially the period from 1930 to 1936 with annual radio/television shows in Germany, when knowledgeable critics each year would write "The mirror screw gave the best picture of any and all of the sets on display." Not even one company was willing to take a chance on investing in the cost of developing a low cost mirror screw.

TEKADE of Germany came the closest in 1935/36 to actually re-



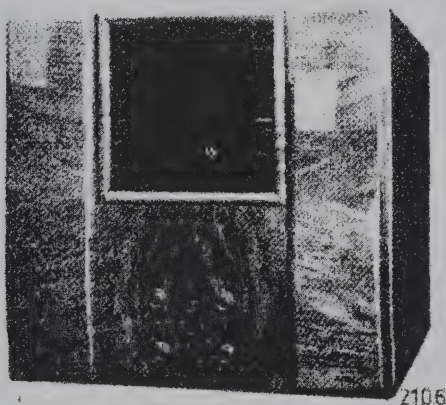
Fig. 37. Mirror screw replica set modelled on the German 1932 set, and entered into the AWA contest in 2008.

leasing drawings for a production model television set using a mirror screw scanner. In 1935 this was presented as a "complete" set, said to provide a white image resolu-

tion of 180 lines. It also included a high frequency receiver and sound system. I have developed a working "replica" of this set based entirely on the two photographs in Fig. 38.

– TEKADE –

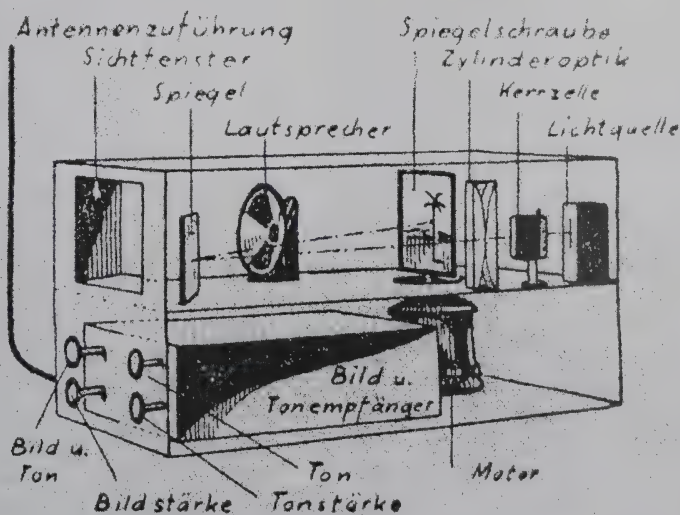
Spiegelschrauben-Empfänger 1935



Technische Daten:

Hersteller	TEKADE
Typ	Spiegelschrauben-Empfänger
Baujahr	1935
Erfindung	Spiegelschraube
Bildröhre	
Bildgröße	30 cm x 30 cm
Zeilenzahl	180
Stromverbrauch	25 Bildwechsel
Empfänger	UKW Super m. Tonempfang
Bild Zf	
Vorverstärker	
Ton Zf	
Hochspannung	
Relativzahl	
Besonderheit	Lichtmodulation mit Kerzele Leuchtmittel

107/ Außenansicht des TEKADE-Spiegelschrauben-empfängers 1935



TEKADE-Fernseher

Fig. 38. Drawings of TEKADE set.

My work on this project came about as a result of my attendance at the April 2008 Narrow Band Television Assn. (NBTVA), in Loughborough, England. Some time before this, in e-mail discussions with Denis Asseman, I came to the conclusion that replicating original equipment as Denis was doing was the way to go. Some of my past work includes material that closely approximates various types of early equipment. My mirror screws are examples that closely resemble the originals in all respects, as do my receivers that are equipped with them.

With that in mind, I decided to "replicate" this mirror screw receiver as my next project. Since there are no original mirror screw receivers of any type available (even their photographs are rare), and it is my belief that TEKADE never actually built one. I had to do as much as I could based on the one photograph in my possession.

I chose this particular German TEKADE set because my latest new and smaller 60-line mirror screw was about the correct physical size. At the NBTVA meeting in England I met a member from Germany, Volker Mohr. I had with me two examples of my 32-line mirror screw and one of my newer smaller 60-line screws, mounted in a complete receiver of another type. I told Volker of my interest in this particular TEKADE set. Volker then e-mailed me from his home to say that he had found a German textbook from about 1932 that included two pictures of the set in which I was interested.¹⁰ He had scanned the two photos and sent them. One photo, a front view of the cabinet, was the same as what I had. The other was very special in that it showed much of the internal construction. What a find this was!

Upon closer examination I

could see that there were some problems with this new photo. It is not a photograph of the set, but appears to be a drawing of someone's concept of one of these sets. Possibly it might be an early drawing of the set to give the engineers something to work towards. The hand written notes in German on the drawing were certainly a help, but how will this set in its final form appear?

Since my intent is for this set to be an operating model, most of the changes I would make would be internal and not visible from the outside. The changes will be with the light source for the mirror screw, the audio system including the speaker, and the complete absence of vacuum tubes. One more change will be the substitution of a 60-line mirror screw in place of the original 180-line mirror screw.

The original video modulated light source for the mirror screw consisted of a bright white point source incandescent lamp, looking into a Kerr cell modulator, and from there passing through a pair of cylindrical lenses mounted face to face. These lenses convert the light to a vertical line of light, one pixel wide. These original parts are not well defined and even if they were obtainable their cost would be high. A substitution was in order, consisting of a set of 24 LEDs, packed edge to edge and side by side.

This work for the most part completed the receiver and it was ready to show. The next AWA Conferece for year 2008 was just a few weeks away. I had planned to enter it in the contest and demonstrate it at the same time, just as I had done before. I decided to elaborate on the test part a bit and possibly get some new, good information for future use.

Over the years, I had noticed

that a certain German reporter, E. H. Traub, who attended the annual Berlin Television Show, always reported the same thing. For at least three years in a row, 1933 - 1935, he said that the TEKADE mirror screw receivers produced the best pictures. I wondered what Mr. Traub might have been seeing.

I decided to have an early design of cathode ray tube showing the same program as a mirror screw. I used a restored 1947-48 model, seven inch Admiral television set with an electrostatic CRT (7JP4), having a design probably dating back to 1938. Figure 39 shows the intended hook-up. It was felt that the difference in the number of image lines would have less of an effect that the picture contrast range and its control as well as the overall picture brightness. All of the equipment performed properly and there was considerable discussion among us. The one thing we agreed to was that the mirror screw provided the brighter picture.

The two photos (Figs. 40, 41) are of my working replica of the 1935 TEKADE receiver. It was successfully demonstrated at the annual AWA Conference in 2009 in Rochester, NY.

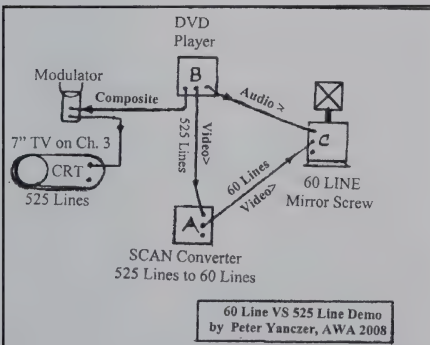


Fig. 39. The mirror screw vs. CRT test hook-up. The same program material appeared on both receivers.



Fig. 40. Replica TEKADE receiver.



Fig. 41. Replica TEKADE receiver, side view.

Based on the receiver proposed by TEKADE, if they could have gotten the cost of the molded/electroplated mirror screw down to \$2 as suggested by their lead engineer Franz Von Okolicsanyi, things may have turned out very differently.



REFERENCES

1. Shiers, G. Early schemes for television. *IEEE Spectrum* 1970;May:24-34.
2. Shiers, G. The rise of mechanical television, 1901-1930. *SMPTE Journal* 1981;June:508-521.
3. German patent 30,105, Jan. 6, 1884; Ref. 7, pp. 440-444.
4. Weiller, L., *La Lumiere Electrique* 1889; Vol. 34: 334.
5. Gardner, D.B. U.S. Patent 1753697. Sept. 17, 1928.
6. ———, *Television Today*, London: George Newnes Limited, 1935.
7. Yanczer, P. Innovative mechanical television. *OTB* 1993;August: 6-10, 20.
8. Yanczer, P. Radio Movies, *OTB*, 1987; August, 8-11.
9. *Der magische Spiegel*, (The Magic Mirror), Berlin: Arena, 1967.
10. Holtschmidt, D. *Fernsehen wie es begann, Geschichte und Technik der Fernsehempfangsger.* (Television-how it started, history and technics of the television-sets), Berlin, 1932.
11. Yanczer, P.F. *The Mechanics of Television*. St. Louis, MO: Experimental Television Society, 1987.

PHOTO CREDITS

All photos are provided by the author unless otherwise noted.

ABOUT THE AUTHOR

Peter F. Yanczer, KØIWX is a longtime member of the AWA, IHRS and NBTv- Narrow Band Television England. Born in Yugoslavia in 1927, Peter immigrated to the U.S. in 1929.

Raised and educated in St. Louis, Missouri, Peter became “tuned into” Radio and Electronics by the age of 10. It was then that Peter built his first crystal set. Peter was fascinated by most things electrical and used his talents while serving in World War II and the Korean Conflict as a Radar Technician.

Graduating from The David Rankin Jr. School of Mechanical

Trades College with emphasis in Precision Machinist and Radio and Television Technology, and Washington University School of Engineering, St. Louis MO. This led to a successful career as an Electronics and Space Engineer with Emerson Electric, also serving as Department Head of the Electronics Laboratory. Peter was a Consultant Engineer at MacDonald Douglas Corporation and served as an Instructor of Electronics for 11 years at David Rankin Jr. School of Mechanical Trades College. Peter remains dedicated today to the preservation, education and historical values of Radio and Television.

Peter received his Amateur Radio License in 1955 with the Call Letters KØIW.

Peter authored the book, “The Mechanics of Television” in 1987¹¹, IHRS Quarterly Booklets and ETS Quarterly Booklets. Peter developed and produced a complete 24 line DIY mechanical Television Camera and Receiver Kit.



Peter Yanczer

AWA Review

Wireless and the Sinking of the *Republic*, 1909

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ABSTRACT

Jack Binns was the Marconi wireless operator on the White Star liner *Republic* when it was rammed in the fog off the coast of Nantucket on January 23rd, 1909 by the Italian liner *Florida*. Using the ship's wireless equipment, which he describes in detail, Binns helped guide ships to the site of the collision—the first rescue at open sea coordinated by wireless. Over 1500 lives were saved—the only lives lost were those due to the collision itself. Binns then used wireless to coordinate towing the badly damaged *Republic* to safety. That effort failed, and the ship sank. On both sides of the Atlantic, Binns was hailed as a hero. With the drama of the rescue, wireless shows became the rage in the US in 1909, with a reluctant Binns as their centerpiece. By 1910, the wireless mania died down, so Binns could resume his work as a Marconi operator.

My grandfather Jack Binns finished the memoir of his early years in 1959, the year he died and 50 years after the sinking of the Republic, the pivotal event in his life. In the following I have extracted his description of how he came to Marconi, and of the wireless system on board the ill-fated Republic, followed by his tale of the role of wireless in organizing the rescue of the passengers aboard the Republic and the Florida, the ship that rammed the Republic, on January 23-24, 1909: it was the first large-scale use of wireless for rescue at open sea.

But first some background about Jack Binns and how he came to be aboard the Republic. Jack was born John Robinson Binns on September 16th 1884, in the Union Poorhouse in Brigg, Lincolnshire, England. His mother was unwed and she left him in the care of his grandmother and uncles, who moved with him south to the market town of Peterborough (Fig. 1).

This town was a major hub of the Great Eastern Railway. Binns quickly finished the required schooling of his day, and at age 13 went to work for the railway's telegraph office. He hadn't been there very long when both his legs were crushed as he scooted under some railway cars to deliver a message. As he was a poor boy with little prospects, the doctors decided to try a new treatment

for the infection he developed rather than amputate his legs. Miraculously the treatment worked, his legs were saved, and he lay



Fig. 1. Jack Binns at about age 2. Photo courtesy of Nicola Pike.

in traction for what turned out to be a privileged year. That year he read everything he could lay his hands on, and taught himself all the physics and electronics then known. When he was released from hospital he was quickly promoted to junior operator, and then was given the charge of the major telegraph route that went from Colchester to the European Continent, and from there on to the East. He felt, however, that this position was leading nowhere and he had learned all it had to offer, so he next signed up with the British Post Office to work at Newmarket, the racing town, where King Edward VII was often found. That too was unsatisfactory, so as he says:

By the time I had completed my term at Newmarket I had become adept on every type of telegraphic equipment in use at that time with the exception of that used on cables and in wireless communication. As the flat racing season neared its end I wrote to the Marconi Company to ascertain whether there was any possibility of securing a position with them. My enquiry was timely, and by the end of 1904 I was in the Marconi school at Seaforth, near Liverpool, undergoing instruction in the new art.

About three months later I was told I had been selected to serve on German merchant ships.¹ I was under instructions to join the North German Lloyd liner *Kaiser Wilhelm der Grosse* at Southampton on her Western voyage to New York in April 1905 (Fig. 2).

Thus it was I began life at sea working with still another means of communication.

By 1908 Binns had sailed on German ships for three years when the German Reichstag decreed that only German nationals could operate the wireless systems on German ships. Thus, after a short



Fig. 2. Jack Binns in his Marconi operator's cap. Personal photograph.

interlude carrying out research for Marconi on the Ostende-Dover run, and six months at the Marconi station near Crookhaven, Ireland, Binns was assigned to the Republic. New regulations concerning licensing of wireless operators had just come into effect in England, so before sailing Binns took the test to earn a Certificate of Proficiency in Radiotelegraphy. To quote Willie Williamson, Archivist for the Radio Officers' Association, UK, who looked up his exam records now held in the Liverpool Maritime Museum:

"He sat his exam on the 25th November 1908 at Marconi's depot at Seaforth in Liverpool. His sending speed was 26 wpm and he received at 29 wpm. His knowledge of "rules" was judged to be fair and his technical knowledge was good. He impressed the examiner who made a special mark that indicated that Binns was, quote, "a good man."² (Fig. 3)

The Republic was built in Belfast at the Harland and Wolff shipyards, the same yards responsible for the Titanic. She was originally built for the Dominion Line, and

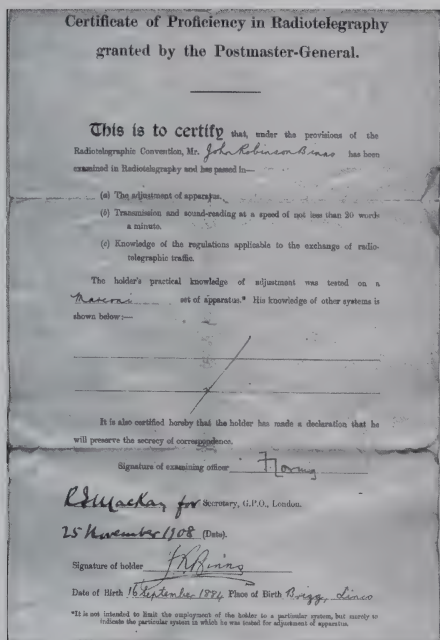


Fig. 3. Binns' Certificate of Proficiency in Radiotelegraphy.

made two transatlantic voyages as the *Columbus*, before being bought by the Oceanic Steam Navigation Company and renamed. She was considered "palatial" at the time—one of the largest most luxurious ships afloat. She sailed with three classes of passengers—280 in first class, 250 in second class, and 2,300 in third class³—and about 300 crew. Among her modern accoutrements were electric lights and refrigeration. Her hull was made of steel, she had two screws (propellers), and she was 570 feet long, just under 68 feet wide, and her draft was 34 feet, with 5 decks and 12 water-tight compartments. Like the *Titanic*, she was considered virtually unsinkable.

Here is Binns' description of the wireless apparatus aboard the *Republic*:

The actual use of wireless telegraphy on regular ocean-going ships was only a few years old at the time the *Republic* was equipped in 1907.

The apparatus and its method of installation were very crude judged by modern standards. As a matter of fact not too much was known about the physics of the equipment; often instruments were in practical use two or three years before their theoretical underpinnings were understood.

The wireless cabin on the *Republic* was an after-thought—as were so many other shipboard installations of that period. It was located abaft the second class deck house (Fig. 4). During the time the ship was employed in the Mediterranean service a bulkhead was erected on each side of the ship at the end of the second class deck-house, leaving the wireless cabin isolated in the steerage married quarters deck. The cabin was divided into two rooms, one of which contained the wireless apparatus



MARCONI STATION, WHITE STAR LINER REPUBLIC.

Fig. 4. The Marconi cabin on the deck of the *Republic* (?). Note its location near the railing and lifeboat. If this is a true picture of the *Republic*'s cabin, this was the lifeboat that was torn away by the *Florida*'s bow, along with the port side of the cabin.

This photo, reversed, was published in the *Evening World*, January 25, 1909 (Library of Congress). I have not found the source of the above version, which was among my grandfather's papers. Unlike the description given by my grandfather, as well as the image of the wrecked deck (Fig. 12), the station in this image does not have a roof made from the deck above it.

and the other was the operator's sleeping quarters—in fact his home afloat. The door originally in the partition between the two rooms had been removed on the previous voyage, and a sliding drapery installed there in its place.

The cabin was built under the boat deck of the second class and the deck itself formed the roof. Over the top of the cabin, on the boat deck, a tall wooden tower had been built to carry the lead-in insulator high above the heads of the passengers and thus keep them away from the down leads of the aerial wires, thereby keeping both the passengers and the wires from injury. Her equipment consisted of the Marconi 1.5 kW transmitter available at that time. The transmitting apparatus included two ten-inch induction coils, capable of producing a stepped up voltage sufficient to produce a fairly good spark. There were high-tension condensers of the Leyden Jar type and an oscillation transformer. These, used in the proper circuitry, gave three wavelengths known in the Marconi service as Tune A, Tune B, and Plain Aerial, respectively. The frequency of the latter depended on the aerial installation on each individual ship and varied accordingly. There was a set of eight large storage batteries for use in emergency. The normal range of the set at full power was about two hundred and fifty miles in most directions under average conditions. The range with storage batteries was about sixty miles.

The aerial (or as Marconi called it, the antenna) was of phosphor bronze wire of forty-two strands twisted in a string-like line.⁴ The aerial was formed by stringing two of these wires in parallel from three ash spreaders, running from the main-mast over the mizzen-mast to the after-mast. The spreaders

were held at each mast by means of strop insulators. From the after-mast, the two wires composing the down leads met at the top of the wooden tower. The whole aerial formed what was known as the "L" type—a type that had a very decided directional effect. It was however the only type that could have been conveniently employed on the *Republic*, which was a four-masted ship⁵ (Fig. 5).

The receiving apparatus was of two kinds—the magnetic detector and the coherer. The latter had been replaced by the more practical magnetic detector, but it was still retained on ships having only one operator as a means of communication while the operator was asleep, since the recording instrument connected with it made a fair amount of noise; the great drawback to the magnetic detector was that the operator had to wear special head telephones constantly while he was on duty.

In the coherer type of receiver, the coherer itself is placed in series with a single cell dry battery and a very sensitive relay. The purpose of the latter was to bring a larger battery to work a bell or Morse recording instrument. The coherer consists of a small glass tube in which are inserted two silver plugs tightly fitting the tube (Fig. 6). The two ends of the plugs facing each other were shaped to form a V-shaped gap, partially filled with a quantity of metal filings. The outer

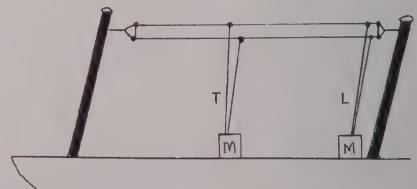


Fig. 5. Diagram of Marconi "T" and "L" type aerials. M indicates the Marconi cabin. Image by VUL.

ends of the plugs have platinum wires soldered on to them leading out of the tube at each end, which are in turn connected up to the cell and relay forming the circuit. All air in the coherer tube is withdrawn and the tube itself sealed off.

The aerial was joined up to one end of the primary of a small transformer, and ground to the other end. The two ends of the secondary of this transformer were joined into the coherer. The filings inside the coherer lying loosely between the plugs offer too much resistance for the passage of current from the small dry cell, but immediately wireless impulses pass through the antenna circuit they cause the filings in the gap to cohere strongly together and form a path for the current to actuate the relay, which in turn closes the circuit that rings the bell or works the recording instrument.

The magnetic detector consisted of an endless band of soft iron wire that is constantly driven slowly forward around two ebonite discs, rotated by means of wind-up clockwork. At one point in its path the band passes through a small glass tube over which is a winding of silk-covered copper wire; this in turn is inside another winding

insulated from it, the two forming the primary and secondary of the transformer. One end of the transformer primary is joined through a tuning circuit to the aerial and the other end to the ground. The two ends of the secondary are joined to a specially designed telephone headset.

At the point where this transformer is located there are two permanent horseshoe magnets fixed in place above them, one where the iron wire enters the glass tube and the other magnet where the iron wire emerges from the tube. The magnets are placed so that they create two opposing magnetic fields. As the soft iron band moves forward, the portion of it near a magnet becomes magnetized. When iron band then proceeds past the next magnet, its magnetization reverses. This constantly reversing magnetization induces a small current in the coil leading to the telephone headset. Whenever wireless impulses go through the transformer, they change the rate at which the magnetization in the iron band reverses: the greater the amplitude of the wireless impulse, the greater the rate of reversal. The magnetization in the iron band in turn induces current in the telephone circuit corresponding to the signals being sent.

All wireless stations carry a supply of spare apparatus and parts. There is also a tool chest containing a large number of tools by means of which the operator can make ordinary repairs in case of emergency.

Such was the equipment that brought aid to the stricken *Republic* and continued in useful operation during the thirty-six hours she was afloat after the collision.

With this introduction to the wireless installation on the Re-

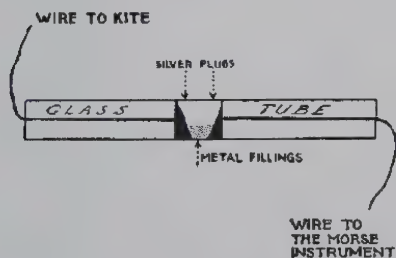


Fig. 6. Diagram of a Marconi coherer, from the description of Marconi's first trans-Atlantic experiment, 1901. Image modified from Marconi's *Achievement. Telegraphing Across the Ocean without Wires*, by Ray Stannard Baker. McClure's Magazine, February, 1902, pages 291-299.



Fig. 7. The Republic. White Star publicity photo.

public, *Binns goes on to describe the events of that January 1909.*

When the *Republic* left her New York pier at three o'clock Friday afternoon, January 22nd 1909, she had on board two hundred and fifty first class and two hundred and eleven steerage passengers⁶ (Fig. 7). The latter were mostly bound for Naples, while the majority of the former were en-route to Cairo via Alexandria. She had a crew of approximately three hundred.

By five o'clock Friday afternoon the *Republic* had passed Ambrose Channel lightship, dropped her pilot, and was off at full speed across the Atlantic shaping her course for Punta Delgada in the Azores, her first scheduled stop. Towards night she ran into a heavy mist. This gradually thickened until the sea was enveloped in an opacous pall of fog that cast everything into obscurity. Captain Inman Sealby and his officers on watch were standing on the bridge listening for the warning note of any other craft that might be in the vicinity. Down

below the passengers had already turned in for the night.

Somewhere in the neighborhood the Lloyd Italiano steamship *Florida* was groping her way through dense fog.⁷ She had on board eight hundred and twenty-six steerage passengers, most of them refugees from the recent disastrous Messina earthquake.⁸ She also carried fifteen first class passengers.

Between four and five o'clock in the morning 23rd of January, these two vessels were so near each other that the foghorn of one was clearly audible on the other. Although both were proceeding with extreme caution they gradually closed in upon one another, and the sound of the foghorns grew correspondingly louder. There was nothing in this to excite alarm because the sirens of ships passing one another in a fog naturally increased in volume as they approach each other.

A little after five o'clock however the foghorns were much too strong for safety, so the two

captains exchanged steering directions by means of their sirens. In the ordinary course of events, after the exchange of such signals, the two ships would have gradually drawn apart. In this particular case the unexpected happened—the *Florida* swung around as though on a pivot and bore straight down on the *Republic*.

Before anything could be done to prevent it, the Italian ship plunged her bow into the port side of the British ship squarely amidships.

The collision occurred about five o'clock on Saturday morning the 23rd of January 1909. At that time I was in my bunk asleep.

I had been waiting till about two o'clock in the morning to get into communication with the *Baltic*, which was overdue, but the Siasconsett land station having told me that he had not been able to reach her as yet, I decided to turn in and get a few hours sleep, since it would be at least four or five hours before we would be within range of one another.

As we were in dense fog the sleep could only be light, as long experience causes one's subconscious mind to alert one immediately there was any change in normal rhythm or change in ordinary surrounding noise.

I was shaken awake by the reversing of the ship's engines. I jumped out of my bunk, and seemingly it was the next second when the collision occurred. A terrible crash accompanied the collision as the *Florida's* bows tore into the *Republic's* side. It was a roar of steel ripping up steel as a mass of eight thousand tons moving at a fair rate of speed crashed into fifteen thousand tons of almost immovable matter. It was the nearest thing to an irresistible object meeting an immovable one that I have

ever experienced.

While I stood on the threshold in the opening separating the two rooms in my cabin, waiting for the crashing noise to finish, the port side and after walls of my cabin splintered up and fell in.

Portions of the boat deck forming the roof of the cabin were also carried away. The telephone to the navigating bridge, which was fastened on the port wall of the cabin, was smashed to bits. Had I been seated at the normal operating position there is no doubt I would have been badly hurt in that mess.

My own feelings would be difficult to describe. Here was something beyond any previous experience. My first impression was that we had run ashore in the fog. I imagined that the sudden retarding force that would result when the ship hit the bottom had caused the walls of the wireless cabin—which were composed of very thin woodwork—to collapse and that the crashing sound was caused by the ship's bottom being ripped open as she ran on the rocks.

This impression was entirely wrong as I found out soon afterwards, but at the time it seemed logical enough. As soon as the crashing noise had ceased I hastily jumped into my trousers and pulled on a coat. I switched on the light and quickly tried the spark to test the aerial. Normally we worked from the ship's dynamo through an appropriate resistance and everything was in readiness for transmitting. My first fear was that the aerial had been carried away. I was almost certain the frail wooden tower must have been shattered in the same manner as the walls of my cabin.

The test I made proved these fears to be unfounded. How the tower managed to escape destruction I have never been able to un-

derstand. The evening before I had been using the wavelength known then as "plain aerial." In this combination the aerial is joined to one side of the spark gap and ground to the other. Unless the aerial is well insulated and absolutely clear of all obstructions, it is impossible to get a spark. It will be readily seen therefore that my quick test proved the aerial was intact. This test had only occupied a few seconds. I had scarcely finished it when the lights went out and the power with which we normally worked died instantly. (I have spoken several times above of connecting to "ground." In this case ground was the ship's metal mass and the vast expanse of the ocean.)

The telephone to the bridge having been destroyed when the walls of my cabin were being demolished, I decided to go to the bridge and report my apparatus in working condition.

I tried to make my way on the port side of the ship, but the deck was cut up and strewn with so much wreckage that it was impossible to make a way through it in the dark.

While trying to get to the bridge on that side, I glanced over the side of the ship and observed a dark object faintly discernible in the water near the ship. The sea was washing over it. This I took to be a rock, thereby strengthening my idea that we had run ashore.

Some time afterwards I found out the object was our number 15 lifeboat which had been torn from its davits just outside my cabin and carried into the sea, and I must have seen it just before it sank or was carried away by the strong current flowing past us.⁹ I came back intending to make my way through on the starboard side, but by this time all the steerage passengers were on deck in a

very nervous state. They huddled closely together making it impossible to get through them. Under these circumstances I went back to the cabin to get into communication with some station, if possible, and inform them of our condition, and then wait for daylight to get to the bridge.

I went inside and switched over to the storage batteries. By this time the insulators were pretty well covered with moisture from the condensation of the fog, and, as the moisture caused heavy leakage, I decided to put a capacitor in the aerial lead. To accomplish this I took a Leyden Jar from one of the cupboards. Among the spare parts we carried was a lot of soft bare copper wire. I quickly twisted a coil of this so as to fit tightly inside the jar. I bent some of the copper wire on the outside, and formed a loop with the ends of the wire. By means of this loop I hung the jar on the primary terminal of the transmitting transformer used with the "Tune A" wave. As the other end of that primary was joined to ground, all I had to do was to join the inside of the jar to the ground side of the spark gap to give me a small inductance, a capacity, and spark all in series and I was on my way!

It was while hanging up the jar that the only accident occurred to the apparatus. The operating key was fitted with a lever on one side in order to change over from the sending apparatus to the receiving equipment. Sending was only possible when the lever was in the down position. A cord was attached to this lever and this cord ran over two pulleys fixed on the ceiling of the cabin. The other end of the cord was attached to a plunger switch. This switch connected with the receiver apparatus when it was in the down position. The plunger switch lifted up when the lever

on the operating key was pushed down, thanks to the cord and pulley system, so the operator could send messages; when the lever was pushed up, the slack in the cord allowed the plunger switch to fall into the down position, ready for receiving any calls or messages coming in from the air. It was a crude but effective arrangement.

In reaching over to hang the Leyden Jar on to the terminal of the "Tune A" transformer, I momentarily forgot the side lever of the key, and while groping in the darkness to find the terminal, I knocked the side lever off the key with my arm, and broke it where it was hinged to the key base (Fig. 8). The accident handicapped me greatly throughout the entire time I was operating. I had to hold the lever in place with one hand in order to make contact and complete the transmitting circuit, so that I could send messages with the other hand.¹⁰

I had just finished fixing these things up—they had taken some time because of the darkness—when Captain Sealby's steward came in. He had found his way through the wreckage. He came with a message from the captain asking if everything was alright with the equipment and myself. I decided to go and report to the captain in person, so following the steward's lead made my way to the bridge. It was from the captain's steward, while on our way forward,

that I learned the cause of our accident.

It was not easy to get to the bridge. The deck was cluttered with wreckage. By going through the second cabin lounge and then making our way to the starboard side and up through the first class companionway to the boat deck we covered the longest but easiest way to our destination. As we came up on the boat deck I found all the passengers lined up on the port side forward of the point where the ship had been hit and the stewards were passing hot coffee. The boats on that side of the ship had been lowered in their davits, and everything was ready for debarkation.

As we came up to the bridge Captain Sealby was standing there talking very calmly and slowly to the assemblage through his megaphone. He was describing the exact state of affairs and adding there was no cause for alarm. He said as soon as the ship that struck us returned they would be transferred to her. Just before we reached him the carpenter came up and reported the results of the soundings he had made in the holds.

In his hand the ship's carpenter held a small lantern—this the Captain took from him and then carefully selecting a cigar from his pocket opened the lantern and lit the cigar. This very cool and deliberate act went a long way to reassure any of the passengers who were at all nervous.

Shortly after this I ran up the ladder to the bridge and reported to the Captain that the station was in working condition and that I expected to get into communication right away. He told me to go ahead and do so, and he would send down a message giving all the particulars. Just as I was leaving him, he took up the megaphone and told the passengers the wireless was in



Fig. 8. Marconi wireless key with side lever. Image courtesy Tom Perera, W1TP Telegraph & Scientific Instrument Museums: <http://w1tp.com>.

working order, and that by its aid he expected assistance would be summoned to us.

This time I managed to get back to the cabin alone. The moment I got back I commenced to send out the distress signal 'CQD' followed by the call letters of the *Republic* 'MKC'.¹¹ The flashing of the spark in the inky darkness was the weirdest thing imaginable, and to the frightened steerage passengers who now crowded round my room, it must have had a most terrifying appearance. Unfortunately I could not keep them away owing to the wrecked condition of my cabin. They swarmed around me, and their talking bothered me a great deal while I was listening for a reply to my calls. One of them sung out to me in a scared voice: "Oh! mister what is the matter?"

I told him to keep quiet, everything was alright, and he would soon taken off the ship if he didn't make a noise. The crowd fell (nearly) silent.

As near as I can remember I had sent out the distress call a couple of times when I heard Siasconsett giving a general call. Apparently he had heard me, but couldn't make my signal out or who I was. Knowing how very weak my signals must be to him I sent very carefully and slowly:

"CQD! CQD! here is MKC MKC shipwrecked."

This I repeated three times, and to my great relief he replied by asking for particulars.

From his style of sending I had already recognized the "hand" of Jack Irwin who was on duty at the time (Fig. 9).

I went at my work with a fairly light heart now, for I knew that if the storage batteries gave out Siasconsett would see that assistance was sent to us as soon as possible; even though I might not be able



Fig. 9. Jack Irwin. Image from Wellman, *The Aerial Age: A Thousand Miles by Airship Over the Atlantic Ocean; Airship voyages over the Polar Sea; The Past, the Present and the Future of Aerial Navigation*. New York, A. R. Keller & Company, 1911.

to get our position to him it could be worked out since it would be quite easy to establish the time we dropped our pilot off at Ambrose Lightship.

Also he would know we were not too far from Nantucket because he would know I was using storage batteries from the type and character of the signals he was getting from me.

As a matter of fact the discharge from the storage battery was so sluggish that rapid sending was impossible. Additionally the frequency of the spark I obtained was so low in pitch that no operator would mistake the source of the power I was using (Fig. 10).

Just after Siasconsett had answered me the Chief Officer, Mr Crossland, came along to enquire whether I had been successful in reaching anyone.

He also brought the Captain's first official message with him. I

called up Siasconsett again, and while the chief waited I tapped out the following:

“*Republic* rammed by unknown steamer twenty six miles Southwest of Nantucket lightship. Badly in need of immediate assistance. Sealby.”

It was very slow work, the accumulators were quite sluggish, and I had to send very firmly indeed to get anything approaching a spark. In addition to this I was having great difficulty with the side lever of the sending key. As soon as I had completed the message Irwin at Siasconsett said:

“OK OM [old man] I will pass it along to the *Baltic* and *La Lorraine* who are now in communicating range. I will also send a message to Woods Hole asking them to send the Revenue Cutter *Acushnet* to your assistance.”

I lost no time in sending this reassuring news to the bridge. Douglas, my steward, was now standing by me and he was kept busily engaged carrying messages to and from the bridge during the entire morning. At this moment another message had come down from Captain Sealby with further details. It read as follows:

“*Republic* rammed in engine room on port-side by unknown steamer. Badly in need of assistance but no danger to life. Position Latitude 40.11 North. Longitude 70 West. Sealby.”

I transmitted this news to Siasconsett as quickly as the sluggish spark would permit. Slow and careful sending was the quickest way to provide accurate reception at Siasconsett. It was tedious work and very trying. It must have been awful for Irwin. The fact that Jack worked with patient energy contributed directly to the success of our rescue. As soon as he had acknowledged receipt, he started



Fig. 10. The power system of the Marconi Station at Siasconsett, Nantucket—much more power from this set-up than can be obtained from storage batteries! Image from the George Grantham Bain Collection, Library of Congress.

transmitting the contents to the *Baltic* and *La Lorraine*.

Some time later I saw Jack in New York and he told me that he had the early morning watch on 23rd 1909. He had become chilled while trying to raise the *Baltic*. He laid the phones down while he put some coal in the stove that was located in the middle of the shack. On replacing the headphones he caught the dull weak pitch of my call. The act of getting up and replenishing the stove had thoroughly aroused him from his chill, and he was all ears when he heard the unusual ‘CQD’.¹²

Although I could hear the *Baltic* and *La Lorraine* very clearly and distinctly, neither of them could hear my disabled spark, which was not carrying more than thirty or forty miles. In consequence all communications from the captains had to be relayed by Siasconsett. The installation there, being on land, was not disturbed by the rattling caused by vibration as it was on shipboard. Even so he had to request all others to remain silent whenever I was sending.

Shortly after he had received our second message by way of Siasconsett I heard Tattersall¹³ on the *Baltic* sending the following

message:

"White Star Line New York ... Received message from the *Republic* of ramming. Will proceed to her assistance. Reach her at 11 oclock. Now 115 miles East of Ambrose Channel. Ranson." (Fig. 11).

After sending this, Tattersall asked Siasconsett to tell me that the *Baltic* had changed its course and was making for us at full speed. He scarcely finished when *La Lorraine* called up the land station, and after transmitting a similar message to the French Line in New York from Captain Tournier, he sent the additional note to Siasconsett, reading:

"Please tell *Republic* we are 120 miles off shall reach her at two oclock pm. *La Lorraine*."

La Lorraine then called up the Cunarder *Lucania*, who was astern of him, and notified the captain of that ship of our accident and to come to our assistance also. The *Lucania* was too far away for me to hear but a few minutes later I heard *La Lorraine* reporting that *Lucania* was also coming to our aid. Irwin then reported to me that the Revenue Cutter *Mohawk* was on its way to us from Woods Hole, Mass.

It was now seven o'clock in the morning and the first streaks of



Fig. 11. Radio room on the *Baltic* with Henry James "Jack" Tattersall (?) at the key. Photo from a contemporary newspaper.

dawn were filtering through the almost impenetrable pall of fog that hung around us, but with this weak but gradually increasing light our work was made a little easier. Just about this time I was able to put the telephone headgear aside for a few moments and finish my dressing. At the time of the accident I had hastily slipped on my trousers and a coat. Exposed to the cold damp air in this scanty attire I had become chilled through and through, and the respite, which permitted me to move around while getting into warmer clothing, was most welcome.

As soon as I had finished dressing I glanced out on deck, and a gruesome sight greeted me (Fig. 12). The railings, stanchions and bitts had all been carried away, twisted beyond recognition, or torn out of their fastenings. Just outside my cabin I saw two bodies. As I looked I saw Dr Marsh, our ship's surgeon, examining them. He reported they had been killed outright by the collision.¹⁴

The injured side of the ship happened to be the on the weather side, and with my cabin wall missing the cold damp fog penetrated into the room relentlessly. There was no heat of any kind: it had gone with the ship's power as soon as the engine room flooded. Eleven years previously I had had both of my legs seriously injured in a railway accident. That they were still part of me was due to the great skill of the doctors who treated me at the time. Because of this old injury my feet were the first to suffer from the intense cold. By this time I could no longer feel them but I had to sit there and do the wireless work—there was no one to spell me.

I was fairly busy all the time now with Siasconsett, but between ten and eleven o'clock in the morning both the *Baltic* and *La Lorraine*

began to read my signals direct. The first message I got from my old pal J. B. Bour, chief operator on *La Lorraine* was:

“Dont worry OM we are bursting our boilers to get to you, and making about twenty two knots.”

At that rate it would not be long before he reached our position. I began to feel much better after receiving that cheery message. By eleven o'clock Douglas, my steward, had succeeded in scrounging a bottle of Scotch whiskey. I took a drink immediately. I do not think I ever tasted anything so refreshing in my life. The blood seemed to flow through my legs again. Despite this the cold was still intense, and the fog blown in by the wind penetrated my clothes, chilling me through and through. I could barely feel my hands and finally had to put on gloves. These greatly retarded my sending, but that was better than not being able to send at all because of frozen hands.

The rest of the day I slowly sipped that whiskey a few drops at a time. Around noon Douglas brought me up some sandwiches he had been able to make in the galley.¹⁵

Shortly after he began to read my signals at first hand, the operator of *La Lorraine* sent me the following:

“Captain *Republic*. Please tell me if you are in fog also if possible your exact position. Tournier, Captain *La Lorraine*.”

We replied briefly to this:

“Captain *La Lorraine*. We are still in fog. ZP (code letters meaning, the exact position of our ship is) Lat 40.17 N. Long 70 W. *Republic*”

Ten minutes later *La Lorraine* sent the following:

“Captain *Republic*. Please tell us depth of water, we want to direct our steering accordingly. *La Lorraine*.”

As I had already received this information from the bridge I re-



Fig. 12. A view of the wrecked deck of the *Republic*. The wireless cabin lies in the background, between the two figures—the ship’s carpenter on the right, and his mate with the sounding rope. You can see the roof leaning across the wireless cabin. Note the two white shrouds on the left among the wreckage, and the linear gashes in the side of the cabin at right, made as the bows of the *Florida* raked the deck. Photo taken by Captain Sealby’s steward, A. Lax; published in contemporary newspapers.

plied right away by informing him that we were in thirty-five fathoms and that Nantucket was bearing North-North-East of us. Poor Bour was having a great deal of difficulty reading my weak signals, especially since now there were so many other stations with their normal power, calling, talking, and sending messages all on the subject of our disaster—but he stuck at it manfully, and kept up a steady run of encouraging chatter in between the official work.

Throughout the day I had to make use of every official and recognized abbreviation in order to conserve the energy stored up in our accumulators. The messages sent in this manner would be unintelligible to the lay mind, so for the purposes of this record I am repeating most of them in full. The same cause that forced me to use abbreviations prevented me from indulging in answers to the encouraging talk that was addressed to me, and kept up by the operators around us. Their remarks were very comforting indeed, and the senders fully understood the reason I did not answer them.

The wireless cabin on the *Baltic* being situated on the after part of the ship on the second class deck over the engine room, her wireless operators were greatly handicapped by the vibration and other noises surrounding them insofar as receiving my signals was concerned. About the time Tattersall began to hear me, Captain Sealby sent down a message, which I then slowly and painfully tapped out as follows:

“Captain *Baltic*. Have picked up Nantucket by submarine bell.¹⁶ Bearing North-North-East. Sounding thirty-five fathoms. Sealby.”

A little after ten o'clock in the morning the *Florida* made her way back to us, and the transfer of our

passengers began—Captain Sealby had decided that the *Florida* was in less danger of sinking than the *Republic*, so ordered all our passengers to be transferred to the *Florida*. This was our first sea transfer in rowboats.

The fog had lifted slightly for a short while and I caught a glimpse of the *Florida* through the shattered wall of my cabin. She was in pretty bad shape. Her bows had been stove in for thirty feet, with a thin strip of them about two feet thick standing straight out with its under part hanging in twisted ribbons.

The fog closed in again, and the transfer continued under those conditions. As soon as this work began Captain Sealby sent a message to the *Baltic* informing her captain that our passengers were being put aboard the *Florida*, and also notifying everybody in the neighborhood of the identity of the vessel that had collided with us. Siasconsett in turn sent the information to the world, and in New York it was on the streets in the early editions of the afternoon papers very shortly thereafter.

Some time after eleven o'clock in the morning the *Baltic* called me and sent a message saying that ship had reached the position given in our first dispatch, but could not observe any sign of us, but he would continue to cruise around in a zig-zag course in an endeavor to locate us. We had undoubtedly drifted considerably from our original position, which would account for the inability of the *Baltic* to find us. The most serious work of the day commenced at this moment, and thereafter every effort was made to bring the *Baltic* alongside us. The *Florida* having no wireless was unable to assist and the whole work of getting the rescuing ships alongside devolved itself upon our

captain by way of the wireless.

At noon I guessed the *Baltic* and *La Lorraine* were within ten miles of us. I reached this conclusion from my experience with the relative strength of signals, especially from long comparison with those emanating from ships within visible distance. I took this opportunity to run along to the bridge and report this information to the captain in person, and my reasons for drawing this conclusion. My steward, and in fact all the crew, were busily engaged in the work of passenger ferrying. Moreover I was glad to get a little exercise and stir up my circulation. Captain Sealby sent back a message asking Captain Ranson to exercise due care as we were completely helpless, and the *Florida* was hove to embarking our people.

From this time on, we and the *Baltic* began to explode bombs at intervals. The times for the explosions were arranged by wireless, and then on both ships the captains and officers listened very intently for the reports. Once or twice it was thought the reports were heard, but that proved to not be the case.

It seemed now as though all the ships in the world equipped with wireless were in the vicinity. Because they were all using the same wavelength—or very close thereto—there was a complete Babel of sounds in my head telephones. Despite this I could read both the *Baltic* and *La Lorraine* with reasonable ease since their signals were so strong due to their nearness to us. The conglomeration of noise however made it extremely difficult for them to read my faint signals.

It was during this trying time I decided that if ever I came out of the mess safely I was going to make very strong recommendations as to the handling of such situations

in the future. There was no doubt in my mind that one station and one station only should assume command and keep order, and that all other stations in the area should obey those commands. It seemed to me that the station best fitted to exercise control was the most powerful land based station, if the event occurred near one. In our case it would have been Siasconsett. In the event no land station was within communicating distance, then it should be the ship with the most powerful transmitter. As events turned out I not only made this recommendation, but I incorporated it in the Marconi Book of Operating Rules, which I was assigned to draft later in 1909.

Just before one o'clock all our passengers had been successfully ferried over to the *Florida* without mishap. This information was sent to the *Baltic*, who in turn relayed it to Siasconsett for transmission to New York. Shortly thereafter Captain Sealby gave orders for the surplus crew to be transferred to the *Florida*, and in response thereto all the firemen, stewards, and other non-deck members of the crew were rowed over. Over two hundred persons were removed in this operation, leaving only officers and sailors—a total of 45—on board (Fig. 13).

La Lorraine called me up around one o'clock and sent this message:

“*Republic!* Tell your captain we can hear his bells and are steering straight to you. Also say he might make as much noise as possible to direct our steering because it is so foggy. *La Lorraine*”

The only means of announcing our presence were bombs and the ship's bells, the foghorn having gone out of commission immediately the engine room was flooded.

We were in doubt as to the

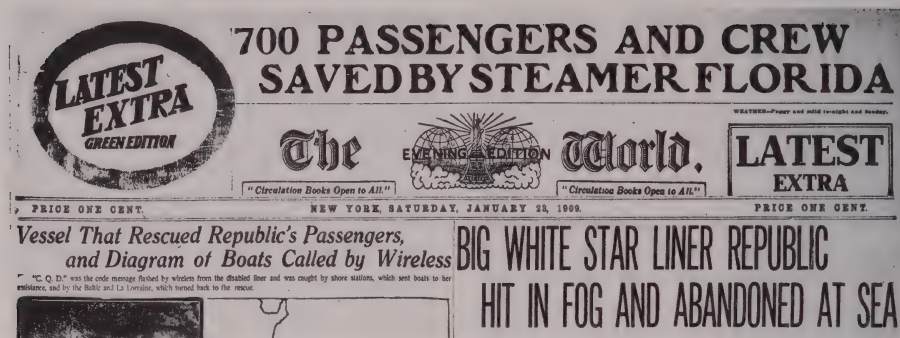


Fig. 13. Headlines in the Evening Edition of *The World*, January 23, 1909. Image from the Library of Congress.

meaning of the *Lorraine's* message, so I asked him if it was our hand-operated bell he could hear. He replied that he meant the submarine bell.

This exchange was important because if he could hear our ship's bell, then he could not be far away and we should be able to hear his foghorn any moment. He must have been mistaken about the submarine bell because we were only equipped to hear such signals—not to produce them. I told him that it must have been the submarine bell on Nantucket Lightship that he heard; it was also audible on our submarine apparatus, and indicated that the lightship was to the North-Northeast of us. *La Lorraine* never found us.

The transfer of our surplus crew was completed without mishap. With them went my steward Douglas. I could have had a sailor told off to carry the messages to and from the bridge, but I was so chilled I found it impossible to sit still any longer, all sensation had left my feet which were like ice. So cold had I become that I eagerly seized the opportunity each message gave me to run up to the bridge, and as I was situated pretty well aft I had to go about a hundred yards each time and climb ladders as well. This greatly helped in re-

storing my circulation.

The first time I went to the bridge, chilled through, shaking head to foot, my teeth chattering like castanets, and scarcely able to talk, Captain Sealby said to me:

"Don't be afraid Mr Binns, we will see that you get off alright."

He evidently thought I was scared from the manner in which I was shaking, but I smiled and told him that it was cold and not fear that caused me to shake and prevented me from speaking audibly. I told him my cabin had been smashed and that there was no protection for me while I was sitting there. Mr Fellowes, the first officer, then very kindly lent me a pair of woolen overshoes, which greatly alleviated the intense numbness in my feet. Someone brought up a bundle of blankets from out of the storeroom, and I took them along with me to wrap around my legs while I was sitting in the cabin.

At three o'clock in the afternoon I heard a message being sent by the Revenue Cutter *Mohawk*. It read:

"*Mohawk* grounded on Tilmers Island at 10 o'clock today in an endeavor to leave the harbor in a dense fog to proceed to the assistance of the steamship *Republic*. Will try to get afloat at high water

at nine o'clock tonight. Cutter *Acushnet* and naval tug assisting. Captain Landrey."¹⁷

Throughout the afternoon we were trying desperately to get the *Baltic* alongside. She was apparently so near, and the prospect of getting her to us seemed so good that we centered our entire attention upon her to the exclusion of the others in the vicinity. How intense the concentration upon the *Baltic* was may be judged from just a few of the messages that were sent by us to her.

"*Baltic*. We can hear a bomb to the West of us. Is it you? *Republic*"

"*Baltic*. Steer North East at once. Sealby."

"*Baltic*. There is a bomb bearing North West from me. Keep firing. Sealby."

"*Baltic*. Can hear your whistle faintly you seem to be off our star-board bow. Sealby"

"*Baltic*. Steer East South East. Listen for our bell. Sealby."

These are but a few of the many that were sent the space of one or two hours. In addition there were also a number of messages from the *Baltic* to us. Steering directions followed one another in rapid succession, so much so in fact, that when placed together as above they appear unintelligible and contradictory. Nevertheless they show quite clearly how the *Baltic* was really steered by Captain Sealby on the *Republic's* bridge through the medium of wireless.

The apparently contradictory steering directions will give an idea of the zig-zag course pursued by the *Baltic* as she proceeded very slowly and with extreme caution in order not to run us down in the thick fog.

It was getting late and everyone on board the *Baltic* and we were doing everything we could to get the former alongside before it

became dark. Messages were flying across the intervening space in rapid succession, and although outwardly calm everyone was a working with feverish intensity, but all our devoted efforts proved inadequate. Darkness began to fall completing the obscurity wherein we lay so helplessly. With the descending darkness our hopes began to fade because it appeared that what we had been unable to accomplish during daylight would be an utter impossibility in darkness.

To add to the gloomy outlook, at six o'clock in the evening it was found we had but one bomb left, and enquiry elicited the same melancholy information from the *Baltic*: she too had only one bomb left. I think from that moment everyone on the two ships who were aware of the exact state of affairs were convinced the task of getting the *Baltic* to us was hopeless—still we all worked with undiminished energy hoping against hope that the unexpected would happen, and—as mostly does in such cases—success crowned our efforts when least expected.

As soon as it was known the two ships had only one bomb left, arrangements were made to explode them at a stated time. I had to explain to the *Baltic* that our telephone to the bridge had been destroyed in the collision, so he would have to allow time for me to get to and from the bridge. One of the first things we did was to check our chronometers by wireless. The *Baltic* arranged the time of his explosion in Greenwich mean-time with his chronometer, and I hurried to the bridge with this information.¹⁸

After a quick conference on the bridge, it was decided that we should form a circle with each one facing outwards as much as pos-

sible, without losing sight of the quartermaster told off to watch the chronometer and signal the exact second by raising his hand.

This was a sort of improvised "direction finding" arrangement, because it was agreed that whoever happened to hear the bomb would stand steady and point in the direction of the sound. By these means a bearing could be taken.

Shortly after the exact second, my well-trained ears detected a faint report coming from a South-Easterly direction. Morrow, the fourth officer, who was standing near me said he thought he heard it too. As soon as the bearing had been checked I hurried back to my cabin with a message from Captain Sealby telling the *Baltic* to steer a North-Westerly course right away and commence firing rockets on the chance of our seeing them above the fog.

Each second of the succeeding hour was filled with anxiety and suppressed excitement. An explosion is generally the precursor of calamity but the explosion we had just heard was the probable forerunner of our rescue—at least that is what we hoped. The *Republic* was in very bad shape. About this time a fairly heavy swell was beginning to run, and she was moving very lumpishly with it. Besides this, the carpenter's frequent soundings of the water level in the hold were not very encouraging.

I sat constantly in my cabin now. A sailor stood by to take any message that might come from the bridge. I dared not remove the headphones for a moment.

About ten minutes after we had heard the report of the *Baltic's* last bomb, the wireless signals of that ship had perceptibly increased. I sent the welcome news to the bridge post haste. Captain Sealby sent down the reply telling me to

inform the *Baltic* to continue on the same course on which he was, and to come with extreme caution. During this time both ships were firing rockets at regular intervals in the hope they might be seen. An anxious half hour passed by during which the operator on the *Baltic* frequently asked if we heard anything of their foghorn, to which I had to continually reply in the negative, but still there was not the slightest doubt regarding the increasing strength of his signals. I told him so. It would be about a quarter to seven when the strength of his signals had become so strong that I could hear the aerial from the receiving gear. This was an indication that he was at most one or two miles away from us. I was in the midst of sending this information when the sailor came down with a message for Captain Ranson from our bridge conveying the information that we could hear the *Baltic's* foghorn from the same direction as the report of the bomb, and asking him to continue on the same course with great care.

Shortly after darkness had descended upon us, the carpenter had brought me a small hand lantern and although its feeble light only illuminated the darkness in its immediate vicinity, still with its aid I was able to hold the broken lever in place on the sending key with greater ease than I would otherwise have been able to. Each time I was sending the spark flashed out with its peculiarly weird bluish light.

Owing to the extreme darkness it was impossible to see the clock, so the times I am giving are only approximations. It was about seven o'clock when the *Baltic's* signals had become abnormally strong indicating his proximity to us, that Captain Sealby sent down a message that read:

“Captain Ranson *Baltic*. Your foghorn very strong. You are too close for safety. Proceed slowly, Sealby”.

This message of apparent danger was to us the harbinger of succor. So good were our prospects now, despite the obscurity in which the fog had placed us, it appeared that nothing but the blackest disaster would prevent the *Baltic* from finding us.

A few more anxious moments passed by during which the *Baltic* was carefully feeling her way toward us, and then a message came down from the bridge, the contents of which practically settled our long but successful work, it read:

“Captain Ranson. *Baltic*. You are very close now. Right abeam. Come carefully. You are on our port side. Have just seen your rocket. You are very close to us. Sealby.”

How dangerous our own plight was can be judged from the repeated instructions to the *Baltic* to “come carefully.” As the collision had occurred in our engine room and stoke-hold the boilers had been put out of commission right away. This not only meant that our engines were useless but also that the engine controlling the huge rudder was also inoperative, since there was no steam to actuate it. As a consequence we were at the mercy of the sea and ever since early morning we had drifted about aimlessly wherever the current had carried us. Then too the stoppage of the dynamos had blackened out our powerful headlights. In their place were the comparatively feeble rays of our oil lamps. Under the circumstances any ship coming towards us would run into us before it was aware of our presence. It was for that reason the repeated admonitions to “come carefully” were sent to the ships

around us.

Approximately at 7.30 pm while I was sending to the *Baltic* a hearty cheer sounded over the crackling of my spark. As we only had a small portion of our crew on board—about forty-five all told—and they were scattered over various parts of the ship, I knew such cheering could not come from them. I left the key and went outside. There in front of me was the *Baltic*—a blaze of light streaming from every porthole piercing the mist that hung around her—a welcome sight indeed!

I had just sat down again to my key when Mr Morrow, the fourth officer, came along with a message reading:

“Captain Ranson, *Baltic*—Come to our leeward and take up our boats. Have *Lorraine* and *Lucania* convoy *Florida*. She is in bad condition. Wireless now closed. Sealby”.

The fourth officer requested me to come on the fore-deck. I had sent the message as we were going to take to the boats. Upon completion of the message I told Tattersall on the *Baltic* that we were about to leave and bade him good-bye, but added that I might see him very shortly. This done I switched off the accumulators and went forward.

I reported to the bridge. Shortly after that we all got into one of the lifeboats, and the oarsmen pulled us around the ship so that we could see how she was sitting in the water.

This completed, Captain Sealby, Chief Officer Crossland and a few others returned aboard the *Republic*. The rest of us rowed over to the *Baltic* (Fig. 14). As soon as I arrived aboard I went to the wireless cabin to say “Hello” to Tattersall and his assistant Balfour. They got me a bunk in the assistant purser’s



Fig. 14. The Republic, as seen from the Baltic. The note pasted by Binns to the back of this photo says: "The white patch amidships is the tarpaulin covering the gash made by the Florida. Close examination shows the ruin caused by the Florida's overhanging bows as she drifted sternward. All the stanchions, bitts, and railing were either carried away or twisted beyond recognition. The wireless cabin just abaft of the mizzen mast [the third mast from the left], had its port wall demolished. The one lifeboat still seen in its cradle was rendered useless when its davits were twisted beyond repair." Binns' personal copy of the photo taken from the Baltic by Republic passenger Ruth McAfee.

room, and I promptly went to sleep for about four or five hours.

Because of the excess passengers and crew, the *Florida* had been lying very low in the water, with its bows dipping dangerously into the waves, so throughout the night our crew ferried all the passengers now on the *Florida* from that ship to the *Baltic*, followed by all surplus members of both crews (Fig. 15). Upon completion of the task, the boats were hoisted out of the water, and the *Baltic* made her way back to the *Republic*. As soon as she was within hailing distance Captain Sealby asked for volunteers from his crew, then on board the *Baltic*, to come over and assist in the attempt to save the disabled ship. He also requested that I should go over to keep the vessel in touch with other craft.

As soon as a sufficient number of men had been selected by the

officers, we were rowed over to the *Republic*, which was laying barely a ship's length from the *Baltic*.

Back on board I went to the wireless cabin and tested the storage batteries, and immediately afterwards I made my way to the after bridge and reported my return to the captain and informed him the apparatus was still in working order. While standing on this bridge, which spanned athwartship above the poop deck, the *Baltic* began on her way to New York. It was quite a sight. As the huge liner slowly drew past us under our stern, all her passengers and those that had been rescued lined her decks cheering vociferously.

During the time that I had been asleep, the *Furnessia* had arrived on the scene.¹⁹ The *Furnessia* was still standing by us, and was the only ship near us as the *Baltic* disappeared in the haze. At this

time I made my way back to the wireless cabin. As the fog had lifted considerably I decided to turn my attention to the aerial before doing anything else. I went up on the deck above the cabin and opened the doors of the wooden tower which contained the lead-in wires and their insulators. They were coated with beads of salty moisture from condensation of the fog and salt spray. I wiped them dry, and covered the insulators with a thin coating of Vaseline. This done, I went back to the cabin.

With the insulators fairly dry and the leakage across them at a minimum I was able to dispense with the Leyden Jar and inductance that I had been using the previous day, and so obtained a small but rather low pitched plain aerial spark. Its range was much better than the previous day's arrangement, and more than balanced the drain on the storage batteries caused by the heavy work they were required to handle Saturday.

As soon as these arrangements were completed I called up the operator on the *Furnessia* to ask how my signals were. He replied they were quite readable but very dull in tone. The *Furnessia* then acted as a relay between Siasconsett and ourselves. One of the first messages I sent was one enquiring about the tugs that had been requested. The land station replied he had no news about them, but would wire New York and let us know as soon as he heard. In addition Captain Sealby sent a couple of messages requesting all possible speed. These first tasks being completed I turned my attention to making the cabin more habitable, as the cold breeze continued to penetrate through the broken walls.

On deck I found a bundle of blankets that had been brought up from the storeroom. I took some of



Fig. 15. SS Florida towed into New York Harbor. Image from contemporary newspapers.

these and with nails out of my tool chest started to nail them over the damaged parts of the cabin. I put up several thicknesses of blankets over the parts and although it shut off the light to the operating room, it made it much more comfortable. While I was engaged in this task Captain Sealby came along. I think it was the first time he had seen the cabin since the collision, and he remarked upon the narrow escape I had, as well as that of the apparatus. The damaged bows of the *Florida* had splintered the lintel over my cabin door, and it was impossible to close the latter. I nailed up blankets over the door so as to leave means of entry and exit, and although the blankets overlapped the cold January air filtered through. Still, the temporary repairs did make the place a little more endurable.

When I had finished this work I sat down and put the earphones on again. It was about this time I heard A. H. Ginman²⁰ at Siasconsett broadcasting the following:

"The *Furnessia* is standing by the *Republic* which seems to ride easier. The deck crew is again on board and the wireless operator is at his post. Tugs have been ordered to the scene. There is a chance to save her. All passengers and unnecessary crew members

are aboard the *Baltic* which is now inbound. The *Florida* is being convoyed by the *New York*. The wireless here is very busy with important messages, please keep off unless absolutely necessary. A. H. Ginman”

Shortly before noon the Revenue Cutter *Gresham* came up and offered to take us in tow.²¹ There followed a consultation and the captains of the three ships agreed on a course of action. The *Gresham* went ahead and picked up our hawser, and we dropped a couple of lines over our stern, which were picked up by a boat from the *Furnessia*. In this manner the *Gresham* began to pull, while the *Furnessia* began to steer.

As the *Gresham* took up the slack in the hawser it fouled our port anchor. The sailors on the *Gresham* didn't see this, so I had to send the following message to her captain:

“Captain *Gresham*. Your tow-line fouling our port anchor. Come to starboard bow and slack up to release it. Sealby”.

During the rest of the day I was kept busy transmitting and receiving instructions from one ship to another connected with the towing operation. Early in the afternoon it was clear the *Republic* had not much life left in her and that it would not be long before she sank.

Just before five o'clock in the afternoon I received a couple of messages for Captain Sealby from his friends ashore. These were relayed to me by the *Furnessia*. I stepped outside the cabin and gave them to one of the sailors to take to the bridge. I stood there for a few moments. It was already dark, but moderately clear. I noticed the terrific slant to the decks, and looking aft I saw the stern rails were in the water. The blue ensign of the Royal Naval Reserves was dapping

over the crests of the waves.²² My cabin was away aft. Most of the deck crew had been sent over to the *Gresham* a little earlier in the afternoon. There were only eight of us left aboard. The other seven were now on the bridge—quite a distance away. I was just about to go to the bridge to report the water was getting awfully close to my cabin when I saw Mr Morrow making his way toward me.

“The captain wants you in the bridge,” he said.

I pointed out to Morrow the condition aft, and he replied:

“Yes! I know. I think we are going to abandon ship.”

And so it was. Within a few minutes after I had reported to the bridge we were in the lifeboats again, pulling for the *Gresham* this time.

We left Captain Sealby and Williams aboard to stay with the ship—they were retrieved from the water after the *Republic* sank.

We watched her disappear as we stood on the deck of the *Gresham*, a noble ship going to her final home in Davy Jones' domain. With her she literally took a part of me, because in one of my cabin drawers there was a small watchcase box with nine pieces of shattered bone that had been taken out of my left leg eleven years before. I had been carrying them around as sentimental mementoes of my accident. With her she also took down to the bottom of the sea all my worldly possessions except those on my body, a condition very little better than that which prevailed when I first arrived on this mundane sphere.

The storm on land after the crew of the Republic and Jack Binns arrived in New York was fierce, and in the first instance, unwelcome to Binns (Fig. 16). In between impromptu parades up

Broadway, Binns and his shipmates were fêted at a number of events, while day after day newspapers were filled with stories of the event told from every possible point of view: captains, wireless operators, crewmembers, and passengers from the ships involved were all quoted at length.

Politicians weighed in, eager to have some of the glitter fall on them. The most publicized of these efforts was the speech given by Representative Boutell of Illinois to the House of Representatives praising Binns, but even officials who had been on the Panama junket²³ with Binns made haste to recall meeting him, according to newspaper reports. Throughout Binns insisted that he was not a hero, that he had only done his duty, and that the engine room men and stokers who prevented the ship from blowing up by releasing the steam from the boilers

were the greater heroes.

A publicity stunt pulled on Binns at the New York Hippodrome was a particular source of embarrassment (and many family laughs since). The Hippodrome was one of New York City's greatest entertainment palaces, with seating for 5,300 and a stage that could hold 1000 people at a time, not to mention elephants, and it had an 8,000 gallon tank that could be lifted up onto the stage for underwater ballets! It was built in 1905 by Frederick Thompson and Elmer Dundy—they sold this show palace later in 1909, but they still owned it when Binns was taken there in January.

Ads had gone out in the New York papers stating that Binns and the crews of the *Republic* and the *Florida* were to be at the Casino Theater on January 28th. The press agent of the Hippodrome, upon hearing this, devised a ruse



Fig. 16. Crowd greeting the *Republic* crew at the White Star office, New York City. The arrow points to Sealby; I believe that Binns' is the second face from Sealby's on the left. Image from the *New-York Tribune*, January 27, 1909; Library of Congress.

to get Binns to the Hippodrome instead, thus providing a windfall of free publicity for that venue. To carry out his scheme, this press agent first invited Binns to a dinner à deux—an excellent and long dinner, which meant that Binns would arrive at the theater as the last act curtain was rising, too late to change plans.

After the dinner, Binns and the press agent got into a hired cab. Not knowing New York that well, Binns thought he was being brought to the Casino Theater (which in fact was near the Hippodrome), but instead the cab delivered the two to the Hippodrome show.

The press agent gave Binns a seat in a conspicuous balcony location, where he was immediately surrounded by the agent's accomplices so he could not escape; stagehands in mufti were set in the audience below. Newspapermen had been informed by telephone that Binns was at the Hippodrome, and that he was going to give a speech. These newspapermen were also set up around Binns. As the show was coming to its end, one of the accomplices in the audience shouted "Where is Jack Binns?" Another accomplice then shouted out that Binns was in the audience, and immediately a spotlight was trained on him. The accomplices began a round of applause while Binns was shoved, then hauled up to the stage, where he stammered a few words, while the chorus girls attempted to kiss him, all to the cheers of the crowd.

Binns managed to escape the first onslaught, only to run down a flight of stairs that took him to the elephant stalls. He tried to hide behind these animals, but despite his now well-decorated clothes—telling this story, my grandfather would roar with laughter about the smelly filth the elephants

provided him—the chorus girls dragged him out and chased him as he ran out of the building. Fortunately he managed to hail a cab and escape.²⁴

Somehow, after he landed in New York City, Binns was persuaded to lend his name to a series of six articles that appeared in the New York Evening World from January 28th to February 4th. In these articles he told of his life as a Marconi man and described adventures gone right thanks to wireless. While Marconi may have put Binns up to these articles, I believe that he was pleased because writing (if in fact he wrote these articles) seemed to him more congenial than going on display—indeed he was later to become a newspaperman, and wrote a prodigious number of articles on wireless and radio, and regular columns for magazines as diverse as Collier's and Popular Science.

On his return to England, Binns and Tattersall were fêted at a dinner hosted by Marconi, and given gold watches, and Binns was given a hero's welcome in his hometown of Peterborough (Figs. 17, 18). No doubt this was when Marconi put pressure on Binns to use his hero status to provide publicity for the Marconi Companies: Marconi was negotiating to have his apparatus and operators placed on ships world-wide, and was probably lobbying heavily for the Wireless Act then under consideration in Congress.²⁵

Binns had left New York in January declaring that he would not sign any contracts for a stage show, even though he was offered \$1000 a week for a ten week stint—probably by Thompson, the owner of the Hippodrome. He said that did not wish to become a "tin god." But on his return trip from England to New York

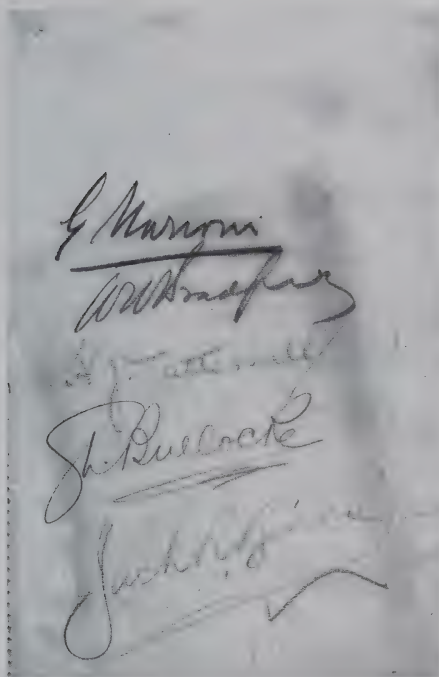


Fig. 17. Back of the menu from the dinner and concert hosted by Marconi honoring Binns and Tattersall, London, February 10, 1909, showing the signatures of G. Marconi, W. W. Bradford (General Manager of the Marconi Companies), H. J. Tattersall, wireless operator of the Baltic, G. L. Bullocke, and Jack R. Binns. G. L. Bullocke was Marconi's assistant on duty at the South Foreland Lighthouse, when he received a wireless message from the East Goodwin Lightship in the English Channel that it had been rammed by another ship in the fog, 28th April 1899. This was the first instance of a message sent via wireless from a ship in distress due to collision with another ship.

in mid-March, he found himself signed up by Marconi to appear in Fred Thompson's hit show "Via Wireless."

In the winter of 1908, Thompson had created a theater extravaganza called "Via Wireless" that became the rage of Broadway. In this play, wireless came to the rescue of a sinking ship. In a case

of nature following art, the Republic incident came at an opportune moment for Thompson; he realized Binns would be perfect as the wireless operator for what was left of the show's run, as well as for the planned reprise of the show for Luna Park in the summer of 1909.

A reluctant Binns labored through the summer at Luna Park, a phase of his life that he never mentioned to his family, or in his memoir. Yet he was a great success. The July 25th issue of the New York Tribune notes that the summer crowds at Luna Park had been enormous, partly due to the fine weather that summer, and partly, according to the Luna Park press agent, due to "Gotynda, the giggling elephant, and "Jack"



Fig. 18. The gold medal received by Binns from the grateful passengers of the Republic, currently in the Peterborough Museum. Photo courtesy of Peterborough Museum and Art Gallery, Great Britain.

Binns as the hero of "Saved by Wireless" ... along with other offerings of 'mastodonic mammothness'." Reviews in newspapers throughout the country echoed this evaluation. But by the end of 1909 Binns' stint in the theater was over.

So why did he leave this path? Perhaps he became disillusioned. Perhaps he had his fleeting moment of fame and publicity, and found it not much to his liking, and now he wanted to get back to earning a steady living in the way he knew best. Perhaps the Marconi Company, which had in all likelihood forced a reluctant Binns to do these shows, in the end had more need of him on ships once the negotiations for installing wireless on ships were progressing well, and the memory of the Republic disaster was fading. Perhaps the Marconi Company finally called him back to London to create the manual he had promised himself to write after the Republic-Florida collision.

In any case, by January 1910 we find him back at sea. To return to Binns' narrative:

"The Adriatic was my first ship assignment after the Republic sank (Fig. 19). I joined her in Southampton on January 26th 1910 shortly before she sailed for New York. Previous to that I had been in the head office in London where I was engaged in rewriting and revising the operating rules for the use of Marconi operators at sea. The Adriatic was commanded by Captain E. J. Smith, commodore of the White Star Line, destined later to lose his life in the Titanic disaster."

The week-end that Binns left the sea was the week-end the Titanic sank in April 1912. The disaster was his first newspaper assignment, and his experience and expertise were used by both



Fig. 19. A dapper Binns in Marconi summer dress, on board the Adriatic, 1910. Personal photograph.

the newspaper he worked for, Hearst's New York American, and by Senator Smith in his hearings concerning the disaster.

Binns continued full-time as a reporter, feature writer, and radio editor for the New York Tribune until 1924, and after that wrote regular columns about radio for magazines.

Despite his love of writing, his restless mind could not be confined to reporting about electronics; he had to have a hand in guiding the field's development. He found his niche in the Hazeltine Corporation—this research company's first asset was Hazeltine's patent for the Neutrodyne circuit. The company went on to develop patents in radio, television, and, during World War II, friend-or-foe (FIFO) recognition systems, as well as carry out research on

radar and sonar. Binns was invited to be assistant treasurer of the Corporation at its founding in 1924, and rose to become its President in 1942, and Chairman of the Board from 1952 until his death in 1959.

ENDNOTES

1. I was informed by John Bowen, who works the Marconi station in Chelmsford, the Marconi headquarters, that the usual term of study at the time was six months, which suggests that my grandfather was unusually adept.
2. Personal communication from Willie Williamson, Archivist for the Radio Officers' Association, UK.
3. By 1907, the White Star Line had exchanged the term "Third Class" for the term "steerage" The White Star Line was known for its relatively comfortable accommodations for Third Class passengers, with proper dining rooms, and smoking rooms (for the men) and libraries (for the ladies). (*Information from a White Star brochure reproduced in <http://www.gjenvick.com/WhiteStarLine/1907-Brochure-WhiteStarLineServices-Boston.html>, accessed 15 March, 2009.*)
4. Phosphor bronze has great tensile strength and therefore can resist the pulling that occurs as masts weave back and forth with the rocking of a ship and the blowing of the wind.
5. Two types of aerials were used on ships, the choice of type depending on the mast arrangement of the ship and the location of the Marconi cabin. If the Marconi cabin was located towards the center of the ship, the lines could go down directly from the center of the aerial, forming a T-type aerial, which was less directional. If the cabin was located towards the stern, as it was on the *Republic*, the down lines had to be attached to the aerial where the aerial meets a mast, forming an L-type aerial. This is particularly true if there
- were other masts located between the fore-mast and the after-mast, because these and their rigging would interfere with the location of down lines. Karl Ferdinand Braun observed the directionality of L-type aerials as transmitters in the course of studying directional receivers. Exploration of the characteristics of these directional systems led him to develop the cathode ray tube!
6. The fact that the *Republic* was not filled to capacity and carried no second class passengers on this voyage has fueled the speculation that the ship carried on board a fortune in gold that was to be secretly transferred to the Tsarist Russian government to prevent them from defaulting on their loans. See: www.rms-republic.com/.
7. The Lloyd Italiano ship *Florida* was one of four virtually identical ships designed for the Italian immigration trade, the others being the *Virginia*, *Indiana*, and *Louisiana*, named in honor of the states of the U.S., the destination of most of their passengers. The *Florida* was constructed in Genoa, and launched June 23rd, 1905. She made her maiden voyage that September, to Buenos Aires. Because she was an immigrant ship—she only carried a handful of first class passengers, and no second class passengers—her interiors were no-frills, but built with an eye to cleanliness. The result was a ship with a distinctly modern air. Up to 1909 she alternated between trips to New York and trips to South America, the former starting from Naples, and the latter from Genoa. After the collision, she limped slowly to New York, where she arrived on January 26th. She was laid up at Morse Dry Dock & Repairs in Brooklyn, one of the most extensive ship repair dry docks, with the world's largest floating dry dock of that time. Her crumpled bows were cut off and a new bow constructed and attached, all within four weeks.

- She remained in service with Lloyd Italiano until 1911, when she was transferred to the Ligure Brasiliana line, and renamed the *Cavour*. In this guise she continued on her trans-Atlantic voyages, bringing immigrants only to South America and no longer to the U.S. By 1914, she plied the same route under the Transatlantica Italiana flag. By a quirk of fate, her end came in the same way as that of the *Republic*—by receiving a blow amidships from another vessel. She was in a convoy on its way through the Mediterranean to Genoa on a foggy night in December 1917 when she was rammed by one of the Italian Navy ships guarding the convoy. Unlike her predecessor, however, she sank almost instantly, with a considerable loss of life. Her wreck now lies off the Catalán coast of Spain, near the harbor of L'Ametlla de Mar.
8. The disastrous magnitude 7.5 Messina earthquake had occurred on December 28th, 2008, and was followed by a forty-foot tsunami that overwhelmed the coasts nearby. The *Republic*—on my grandfather's first trip with her—visited Naples on December 30th, so he saw (and wrote about) the aftermath.
 9. As Binns notes, the ocean currents—specifically the Gulf Stream—are swift (at 5.6 miles per hour) at this location. Incidentally, the Gulf Stream was also the cause of the dense fog in the night of January 22nd-23rd 1909: the warm water evaporates into the cold air and condenses.
 10. Binns was left handed, but was forced to write with his right hand (as were all children in his day). Thus normally he could send with his left hand while writing with his right, a very convenient arrangement. The lever he broke off was on the left side of the key, so in order to complete the circuit for sending, he had to hold the lever on to the operating key with his left hand while sending with his right. This configuration slowed down his sending rate considerably, and was very uncomfortable for him—but under the circumstances a slow sending rate was required.
 11. The “CQ” was derived from the wired telegraph signal used to call all stations to attention. The “C” came from “call.” The choice of “Q” to follow “C” came from the following facts: it is a rarely used letter in Western languages; in European languages it was never used without being followed by a “U;” and the series of dots and dashes used to form “Q” in the Continental code was unusual. As a result “Q” was triply distinctive. Therefore, by international agreement, “Q” was used in the short-hand codes for wired telegraphy—the ones calling all stations, but also in other situations where an abbreviation was useful. In 1902, with the development of wireless for use at sea, Marconi adopted “CQ” but found that it was too general for purposes involving distress calls—minor mishaps showed the call could be easily ignored. Therefore Marconi added the “D,” for distress, to the call to all stations. He published Circular No. 57 on January 7th, 1904, which stated: “...on and after February 1, 1904, the call to be given by ships in distress or in any way requiring assistance, shall be “CQD. All stations must recognize the urgency of this call and make every effort to establish satisfactory communication with the least possible delay...”
 12. Here is Jack Irwin's story of receiving Binns' signal (*Radio Broadcast Magazine*, Volume 5, p. 416, September 1924.): “It was a bitter cold night and the small coal stove was going to its full capacity. With nothing to do and a clear station file, I read and dozed, then dozed and read in my chair. I had not had much sleep the previous day, having gone into the town of Nantucket on errands. The fire in the stove became low and I suddenly became fully alert, chilled. I arose to heap some coal

on the fire but as I did so I heard a faint signal and paused to listen. Dimly I could hear what sounded like a station calling CQ, meaning "all stations." This is the call ship operators broadcast when they came on watch after being away from their apparatus and wish to learn who is within their range.

Listening intently I could not hear him sign his call letters, so at the moment, I paid no further attention. The fire was replenished, the work of a minute or two, I was again listening-in, lazily stretched in my chair. This time I detected something clearer coming into my head phones. CQD, CQD CQD-MKC MKC MKC. It flashed upon me in a second that here was a ship in distress. Throwing in my switch I started the dynamo and answered him."

13. According to Willie Williamson, Archivist for the Radio Officers' Association, UK, Henry James Tattersall and his assistant on the *Baltic*, Gilbert Balfour, took their examinations for the Certificate of Proficiency in Radiotelegraphy the day after Jack Binns. To quote Williamson: "Gilbert William Balfour was aged thirty-three and born in Liverpool. He attained a sending speed of 30 wpm for sending and 31 wpm for receiving and, although the examiner noted he "lacked experience," he also indicated Balfour was "fit to be put in charge of a simple station." Clearly Balfour, despite his lack of sea experience, was a very good Morse man and it is possible he had been a telegraphist with the General Post Office or with one of the many railway companies. The *Baltic's* 1st Wireless Operator Henry James "Jack" Tattersall was born in Upper Norwood on 12th January 1886 and joined Marconi in 1904. He took his exam at Liverpool on 26th November 1908. His sending speed was 22 wpm, his receiving speed 20 wpm."

14. In addition to the two passengers killed outright by the collision, there were four sailors killed

in the bows of the *Florida*, and one passenger on the *Republic* who died of his injuries from the collision after arriving in New York. These were the only lives lost in the entire event.

15. According to the New York Tribune, January 27, 1909, Binns said of James C. Douglas on arrival in New York City:

"Here's a man you ought to write about," said Binns; "he saved lives. Last night was the first that he has slept since the accident. He was with me all the time. He carried my messages back and forth, and kept me supplied with food. He did not desert me once, and if it had not been for him I would have had a pretty hard time."

16. Sound waves can move through water more easily and can be heard at greater distances than can sound waves carried through air. At the end of the Nineteenth Century several parallel efforts were carried out to develop a means of sending and receiving sound signals to improve navigation. The Submarine Signal Company, founded in 1901 in Massachusetts, improved on the early work by creating a better microphone to pick up the sounds transmitted through the water. This microphone was installed in a casing containing water attached to the side of the ship (see picture below). This arrangement isolated the microphone from the air vibrations coming from the ship's machinery. By placing these receivers at either side of the ship towards the bows, the person steering the ship could compare the intensity of the sounds coming from each of the microphones in the tanks. The ship could then be steered so that the signal from each side of the ship would be of equal intensity—in this way they could steer towards the source of the bell.
17. The *Acushnet* never got to the *Republic*. After she was summoned by Jack Irwin using his land line to Wood's Hole, she either went aground near Newport, Rhode

Island in her efforts to reach the Republic, (see: <http://www.ibiblio.org/maritime/photolibrary/index.php?cat=1552>, accessed January 19th, 2009) or, according to Jack Irwin, encountered a four-masted sailing ship on the rocks and was compelled to rescue her crew (Radio Broadcast Magazine, Vol. 5, p. 417, 1924).

18. The question of time aboard ship is an important one (and became particularly significant in the course of the Titanic hearings). Confusion about timing comes from the fact that ships ran according to their own time, which changed as they crossed the Atlantic. There were many schemes for these changes. The original scheme in the Nineteenth Century was to change the time at noon, when a ship's officer could take the ship's bearings from the sun. However, by the end of the Nineteenth Century, in order to keep activities running smoothly in large passenger ships, the times were changed at midnight. For example, the Titanic struck the iceberg at around midnight, when ships around her were changing their times. Each ship had its own calculation for the time change: it did not match an hour, but rather that fraction of the hour that was appropriate for the distance and direction the ship had traveled, given the five hour difference between Greenwich Mean Time and Eastern Standard Time and the fact that the liners did not change time the day before their expected landing. For these reasons, the wireless operators on the Republic and Baltic determined their timings based on Greenwich Mean Time.
19. The *Furnessia* was built in Barrow-in-Furness, north of Liverpool, and launched in 1880. According to the New York Times of March 3, 1881, documenting her arrival in New York on her maiden voyage, she was the largest ship afloat at the time, 5,495 Gross Registered Tons. For comparison, the Republic was 15,378 GRT, and the Titanic 46,329 GRT. The *Furnessia* was one of the last iron-hulled ships to be built—steel proved to be a much better material: steel was less likely to rust, and because of its tensile strength and decreased brittleness when compared to iron, it allowed for the construction of significantly larger ships. Further, the *Furnessia* was one of the last trans-Atlantic steamships built with the possibility that she could, if necessary, move under sail, hence her tall masts. She traveled regularly between Glasgow and New York. She was scrapped in 1911.
20. A. H. Ginman had a long and distinguished career with the Marconi companies. Born in England, he first joined the Cuba Submarine Cable Company in 1895, and remained with that company until joining the American Marconi Company in 1901 as head of the Siasconsett Station. In 1910 he went on to Marconi's West coast and Asian endeavors, in the course of which he established the first radio service between San Francisco and Honolulu, and explored the functions of the Alaskan stations, where he noted that "The climatic and radio stray conditions are shown to be unusual. Remarkable directive absorption is encountered." (see Ginman, A.H., *Radio in Alaska*, Proceedings of the IRE Volume 4, Issue 3, June 1916, pp. 221 - 231). He returned to England in 1917. After World War I, as the Marconi representative in China and Japan, he negotiated the establishment of a number of stations, and then helped establish a joint venture between the Marconi Wireless Telegraph Company and the Chinese government in 1920. In 1928, he returned to England in the capacity of Joint General Manager of the company, and then General Manager. His next assignment was as President of the Canadian Marconi Company, from 1935 (or 1933?) to 1951. He retired that year,

and died in Montreal, November 8, 1954. (Outline for this note was obtained from his obituary, New York Times, November 9, 1954, and from Marconi Company sources.)

21. One of the reasons it took the *Gresham* a long time to find the *Republic* was interference by radio amateurs. Here is the text from the Christian Science Monitor, January 28, 1909, page 2:

Captain Says Amateurs Interfere With Wireless

"Our wireless was interfered with constantly by amateurs while we were searching for the *Republic*," said Capt. K. W. Perry of the revenue cutter *Gresham* Wednesday night. "We have long felt the necessity for some regulation in the use of wireless outfits, but the imperative need of such regulation has been demonstrated in the experiences of the past few days. We were given four different locations of the crippled steamship, to all of which we went. At last I telegraphed the department at Washington. The reply was delayed 12 hours, and the delay was caused by sending private messages and the interference of amateur operators."

22. The Royal Navy Reserves at the time consisted of men who were professional seamen and qualified merchant-navy men, as was Captain Sealby.
23. Binns had been the Marconi operator on a ship carrying members of Congress to inspect the Panama Canal then under construction in 1907. He had joined the members on their field trips, and became friends with many of them.
24. There is an alternate version of this story—not the one my grandfather told, or as described in the New York Times—in which the dinner attended by Binns' companions as well, and was across the street from the Hippodrome, at the Army and Navy Club, and that his companions, together with the press agent, convinced him to see the water show at the Hippodrome.

Which of these stories is true, I don't know, but my grandfather being chased by the chorus girls was in every published account, as well as of course, my grandfather's own telling of the event.

25. In the "American Review of Reviews", January-June 1909, by Albert Shaw we find:
"Lessons of the "Republic" Collision: Perhaps the most noteworthy fact in connection with the loss of the White Star steamship *Republic*, which was sunk in the fog off the coast of Nantucket Island on the morning of January 23 in collision with the Italian liner *Florida*, was the efficacy then proven of the equipment and organization for safety of travel at sea which now obtains on all great modern sea-going vessels. Less than a generation ago an accident involving an equal number of men (1600) would, beyond a doubt, have resulted in the death of all or almost all on board both ships. Thanks, however, to the staunchness of the two great ships themselves, the water-tight bulkheads, the discipline and organization of the crews, and the marvelous facility for calling aid which was made possible by the use of wireless telegraph apparatuses on the *Republic* and the ships that answered her calls, only five human lives were lost in this collision—two passengers in the *Republic* and three of the crew of the *Florida*. All of these came to their death from the impact of the collision and none from drowning. The officers and men of all the vessels concerned behaved with exemplary discipline and coolness ... On February 16, the House of Representatives passed the Burke wireless bill. This provides that all ocean-going ships carrying more than fifty passengers and traveling 200 miles or more shall be equipped with a wireless instrument and operator. The bill prescribes a penalty of not to exceed \$3000 or imprisonment for not to exceed one year, or both

for violation of its provisions. One year is allowed for the installation of equipment."

President Roosevelt staunchly supported these measures. Here is the text of his message to Congress, according to the New York Times of February 9, 1909:

"To the Senate and House of Representatives:

Your attention is invited to recent events which have conclusively demonstrated the great value of radio-telegraphy, popularly known as 'wireless' telegraphy, as an instrumentality for the preservation of life at sea.

While the honor of the first practical application of the scientific principles involved may belong to another country, it is gratifying to know that our inventors have been quick to seize upon and develop the idea, and that several systems of approved scientific merit and commercial practicability have been put into operation in the United States.

Furthermore, through the liberality of Congress and the intelligence and industry of the Navy Department, our Atlantic, Gulf, and Pacific Coasts are equipped with a chain of shore stations, designed primarily for the National defense, but capable of receiving and transmitting messages by any of the systems of wireless telegraphy now in general use. Even our distant insular territories and Alaska are so equipped. So far as our own country is concerned, steps have been taken effectually to prevent the establishment of a monopoly in the practical use of the new applied art.

I deem it highly desirable that the Congress, before adjournment, should enact a law requiring, within reasonable limitations, as determined by what the Government of the United States has already done, and by what prudent and progressive ship owners have already found practicable, that all ocean-going steamships carrying considerable

numbers of passengers on routes where wireless installations would be useful should be required to carry efficient radio-telegraphic installations and competent operators. The subject is now under consideration by the Congress, and I advised that legislation to effect the same general purpose is also under consideration abroad.

Our interest in its enactment is keen on account of the great number of steerage, as well as cabin, passengers who annually arrive at and depart from our ports. What we have already done along practical business lines warrants the United States in being the first among nations to enact a statute requiring the use of this safeguard of human life.

Theodore Roosevelt.

The final act was approved June 24, 1910, and was entitled "An Act to require apparatus and operators for radio communication on certain ocean steamers." The provisions were as follows:

SEC. 1. That from and after the first day of July, nineteen hundred and eleven, it shall be unlawful for any ocean-going steamer of the United States, or of any foreign country, carrying passengers and carrying fifty or more persons, including passengers or crew, to leave or attempt to leave any port of the United States unless such steamer shall be equipped with an efficient apparatus for radio-communication, in good working order, in charge of a person skilled in the use of such apparatus, which apparatus shall be capable of transmitting and receiving messages over a distance of at least one hundred miles, night or day: Provided, That the provisions of this Act shall not apply to steamers plying only between ports less than two hundred miles apart.

SEC. 2. That for the purpose of this Act apparatus for radio-communication shall not be deemed to be efficient unless the company installing it shall contract in writing to exchange, and shall,

in fact, exchange, as far as may be physically practicable, to be determined by the master of the vessel, messages with shore or ship stations using other systems of radio-communication.

SEC. 3. That the master or other person being in charge of any such vessel which leaves or attempts to leave any port of the United States in violation of any of the provisions of this Act shall, upon conviction, be fined in a sum not more than five thousand dollars, and any such fine shall be a lien upon such vessel, and such vessel may be libeled therefor in any district court of the United States within the jurisdiction of which such vessel shall arrive or depart, and the leaving or attempting to leave each and every port of the United States shall constitute a separate offense.

SEC. 4. That the Secretary of Commerce and Labor shall make such regulations as may be necessary to secure the proper execution of this Act by collectors of customs and other officers of the Government.

Under this act, the Secretary of Commerce and Labor organized the Radio Service on July 1, 1911. The Radio Service was composed of three inspectors, with headquarters at New York, NY, Baltimore, MD, and San Francisco, CA.

rently on the faculty in the Division of Nutritional Sciences at Cornell University in Ithaca, New York. Her work on her grandfather's memoir is a labor of love for her "Binnsy," of course, but it also brings her a chance to explore both physics and history, two of her intellectual loves.



Virginia Lovelace

ABOUT THE AUTHOR

Virginia Lovelace, MD, the granddaughter of Jack Binns, was born in New York City in 1943. She was close to her grandfather, and became the guardian of his memoir on his death. She attended Washington University, where she majored in Physics, and then Columbia University's College of Physicians and Surgeons. After receiving her MD degree she became a Board-certified pediatrician, and was a post-doctoral fellow at the Rockefeller University. She is cur-

Letters to the Editor

DUNWOODY'S FIRECRACKER DETECTOR

In the 2009 issue of the AWA Review I wrote an article on early coherers and detectors which included the H. C. Dunwoody "firecracker" detector—the first crystal detector configuration to be used in the De Forest Telegraph Co. system in 1906. This detector, which was made by wrapping wires around opposite ends of a mass of carborundum crystals, was an abject failure and was quickly replaced by another design developed by Greenleaf Pickard on behalf of the DeForest Company—a company later to be controlled by the United Wireless Co. At the time I wrote the article, it was not clear to me why this configuration was characterized as a firecracker, nor was it clear exactly why the firecracker configuration was an abject failure—as reported under oath by several De Forest employees.

Shortly after the 2009 *Review* was published, I visited the George Clark *Radioana* Collection at the Archives Center in the American History Museum and, quite by chance, I came across a photograph of what was characterized as the last specimen of this detector in existence. The text in this photograph reproduced here as Fig. 1 reads: *"This 'Carborundum Firecracker' was THE forerunner of all 'crystal wireless receivers'. It is the first type used, and as far as known, the only specimen remaining in existence. It was invented by General H. C. Dunwoody of the United*

States Army for which he obtained a patent on December 4, 1906." It is now obvious from this previously unpublished photograph why Dunwoody's first detector was called the firecracker. Parenthetically, the author of this plaque was quite incorrect in his assertion that the firecracker was the forerunner of all crystal wireless receivers; a number of earlier crystal detectors used in commercial wireless receivers were identified in my article.

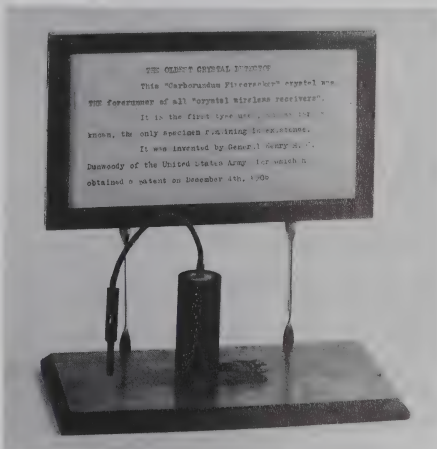


Fig. 1. Dunwoody's carborundum detector first used by the De Forest Company in 1906 was characterized by employees as the "firecracker." (George Clark Collection, Archives Center, National Museum of American History)

The firecracker detector was quickly replaced by a second version designed by Greenleaf Pickard—most likely one with the same "form, fit and function" as the as the firecracker with its spade mounting lug and banana plug connector. A

search of the literature uncovered a photograph of just such a detector on page 133 in Alfred Powell Morgan's book *Wireless Telegraph Construction for Amateurs*. This detector with a spade mounting lug and banana plug identified as the "vertical type" of detector used by United Wireless is reproduced here as Fig. 2. Clearly, this was the detector that replaced the firecracker.

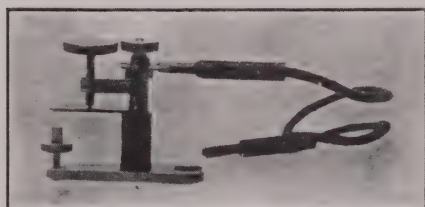


Fig. 2. The ill-fated firecracker detector was quickly replaced by this improved vertical configuration having the same "form, fit and function" as the firecracker. (Alfred Powell Morgan, *Wireless Telegraph Construction for Amateurs*, 3rd ed., 1914, p. 133.)

I previously cited Picard's reason for the poor performance of the firecracker: "*The reason why it rarely worked was obvious from its construction: the two wire wrappings formed more or less equal contacts, in series and in opposition, so usually cancelled out.*" This explanation is somewhat disconcerting because if it were true, then the DeForest Company would have known from the outset that the firecracker configuration would not work, raising the question as to why any company would choose to manufacture and deploy a detector configuration that it knew from the outset would not work.

In order to determine whether or not Pickard's assertion was true, I measured the I-V characteristics and the audibility threshold of several firecracker mockups—two of which are shown in Fig. 3—and compared them with those from selected carborundum detectors manufactured by the

Carborundum Co. which used a pointed carborundum crystal imbedded in Wood's metal similar to the first figure appearing in U.S. patent No. 1,708,572 (reproduced here as Fig. 4). Note the pointed carborundum detector imbedded in Wood's metal is the same configuration Pickard drew in his notebook reproduced as Fig. 46 in the article referenced above.



Fig. 3. Mockups of Dunwoody's firecracker were fabricated to measure I-V characteristics and audibility thresholds.

To my surprise I found that the firecracker configuration had almost the same audibility threshold as the best of the Carborundum Co. detectors, which the company claimed to be one of the most sensitive of the era. I also compared the audibility thresholds with the modern 1N34A detector, which I have often used as a standard for comparing the audibility threshold of a variety of detectors. The minimum detectible signals (audibility thresholds) using a Brandes Superior 2000-ohm headphone were measured for the most sensitive example of each of the three detector types using a 1-MHz cw carrier modulated to a depth of 50% by a 1-KHz audio tone. The minimum detectible audio signals for all three detector types were produced by 1-MHz carrier signals with p-p amplitudes between 30 and 40 millivolts applied across the detectors—that is to say, the minimum detectable signals were essentially the same for all three detector types.

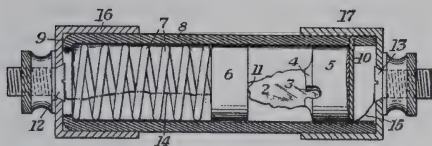


Fig. 4, The response of the firecracker detector was compared to the response of the most sensitive of seven identical commercial carborundum detectors of the form pictured here, which were manufactured and marketed by the Carborundum Co. in the 1920s. (U.S. Patent #1,708,572)

To test Pickard's assertion regarding signal cancellation in back-to-back configurations, I then selected two Carborundum Co. detectors with approximately equal audibility thresholds and placed them back-to-back and, indeed, found that the audibility threshold dropped dramatically just as Pickard posited for back-to-back configurations. It appears that the firecracker configuration—even with its apparently symmetric contacts—has significant asymmetry and does not produce signal cancellation in the same way as two separate carborundum detectors placed back-to-back. The measured I-V characteristics confirmed there is some cancellation in the firecracker configuration, but it was not substantial.

One can only assume that the real reason for the abject failure of the firecracker detector was that this detector—like virtually all early crystal detectors—became insensitive over time and/or as a result of exposure to large electromagnetic pulses, requiring periodic adjustments. Since adjustments were not possible with the Dunwoody firecracker configuration, the performance of this detector must have declined over time, eventually becoming useless for commercial work. It is notable that the detector design of Fig. 2 which replaced

the firecracker also had physically symmetric electrodes—but unlike the firecracker, it was adjustable.

Eric P. Wenaas

MEISSNER REGENERATED REVISITED

I would like to comment on two statements in Mike Murphy's interesting contribution "Meissner Regenerated" in the *AWA Review*, vol. 22.

On page 278 he wrote: "The Lieben Valve...Lee de Forest's Audion hard valve and Robert von Liebens soft valve." I don't think that one may call de Forest's Audion a hard valve; the valve still contained residual gas under low pressure, which could not be removed by vacuum pumps of that time. The same is true for the Lieben valve, which contained mercury vapor under low pressure perhaps deliberately or accidentally. In either case the ionized gas produced a blue glow in the valves under operation. The importance of this was noted by DeForest (1914), and Langmuir (1915).

Secondly he quotes on page 283, left column. "Strauss however, merely applied such retroaction for intensification of received signals... and apparently did not consider the valve as being capable of use for generation." I have reproduced a copy of an Austrian oscillation patent by Strauss (No. 71340) and enclosed it.

I have also provided an excellent reference on oscillator circuit history, (Paulet, 1926).

Of course it is desirable to describe the radio history as precisely as possible, but I think in the year 2010, almost 100 years later, priority should be of no concern.

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REFERENCES

- De Forest, Lee. "The Audion – detector and amplifier, *Proc. IRE*, vol. 2, no. 1 (March 1914), pp. 15-36: "Does the blue coating which forms on the plate render the Audion less efficient?"
- Langmuir, Irving. "The pure electron discharge and its application in radio telegraphy and telephony" *Proc. IRE*, vol. 3, no. 3 (Sept. 1915), pp. 261-293, reprinted in *Proc. IEEE*, vol. 72, no. 5 (May 1984), pp. 613-624. A very comprehensive discussion of this problem can be found on page 618.
- Paulet, W.H. "Fundamental receiving patents". *The wireless world and radio review*, July 21, 1926, pp. 99-101.

MICHAEL MURPHY RESPONDS

Thank you Herr Stoll for your letter concerning the state of vacuum technology during the early years of thermionic oscillatory experimentation, which was occurring simultaneously worldwide in the 1912 – 15 time period. This field of study, that is, the importance and development of vacuum technology and how it influenced incandescent lamp development, the two element devices like rectifiers and finally amplifying and oscillatory three element devices is fascinating and deserves a rigorous approach. I can not begin to do this in answering your letter, but I can recognize my error in some oversimplification of this complex area.

The problem with my characterization of the Lieben Valve being a *soft* valve and the Audion being a *hard* valve, was that likely both were *soft* in terms of the mm of mercury of pressure which could be achieved later, say by 1919-20. As you stated, certainly the presence of a blue glow would indicate that ionization was taking place within the Audion tube.

The real distinction between the

valves was not the pressure itself; it was how the devices were designed to operate. Was the low pressure actually part of the tubes functional design as with the ionization of the Lieben Valve *gas tube* or was it a nuisance as with the Audion which would be considered to be purely an electron charge device? Of course as you infer, possibly the Audion's operation was not so pure in actual operation! But it is apparent that the goal was to remove as much air (impurities) as possible and the better the vacuum achieved, the better the device performed.

The description of the state of the art in thermionic emission purely by space charge, which requires a perfect vacuum, was made ahead of its actual possibility. But Fleming knew that improvements in vacuum were close at hand.

Fleming (1919), provides an excellent resource since the author had the privilege of looking back into the immediate past. This book gives a fantastic snapshot of the state of vacuum technology in the time period mentioned. First let's look at a valve designed to be *electronic*.

"If traces of residual gas are present then the impact on its molecules of the electrons emitted from the hot body, now called negative thermions, will give rise to positive and negative gaseous ions. These positive ions are drawn by electric attraction to the hot cathode and disintegrate it in time. Also the ionization increases greatly the current for a given potential difference (PD) of hot and cold electrode or, what is the same thing, reduces the PD required for a given current. If the gas pressure exceeds 0.0001 mm., then irregularities are introduced into the form of the characteristic curve, and with pressures of about 0.001 mm. the

current may jump from one value to another, even when the PD remains constant, as already noticed by the author. If, however, the vacuum is made as high as a millionth or, better, a hundred millionth of a millimetre of mercury, which needs extraordinary precautions, then the phenomena consequent on ionization of residual gas are absent and the whole effects are due to pure electron emission from the hot cathode.” (Fleming, 1919).

And now a gas tube; the Lieben Valve...

“To overcome the problem of obtaining a high vacuum – a problem that could not to be solved with the air pumps then available – they decided to switch to valves filled with a certain amount of mercury vapor. Following this path meant they had once again to take part in the discourses on electrical discharge of gases, especially on the effects of ionization. In doing so, the Lieben valve changed radically. The two patents from 1910 show the different constructions, especially the introduction of the grid, which can be understood as a simplification of the former arrangement of the electrodes – thus making the valve more reliable. Nevertheless, there were still problems as regards the dependence on temperature and the stability of the pressure of the mercury vapor.” (Blumtritt, 2004).

The second problem with my review piece as outlined by Herr Stoll involved a quote that I included in the work; “Strauss however, merely applied such retroaction for intensification of signals...and apparently did not consider the valve as being capable of use for generation.”. From *Wireless Telegraphy with Special Reference to the Quenched Spark System*

(Leggett). Herr Stoll sent me a beautiful Strauss Patent entered in 1912 and granted in 1915 (PATENTSCHRIFT Nr. 71340) which not only has two variations of what we now call a Meissner or Armstrong oscillator complete with primary and tickler but it also has a translated title: Device for the Production of Electric Oscillations...

In closing, Herr Stoll reminds us “Of course it is desirable to describe the radio history as precisely as possible, but I think in the year 2010, almost 100 years later, priority should be of no concern.” I think when he says “priority” he means “who are the real inventors of radio and who should get the credit?” It may well be moot at this point, but some of us have not seen this information before. Many have no idea about the foundational contributions of European, especially German and Austrian engineers for various reasons, including patent actions, and intentional bias stemming from two world wars and the subsequent rewriting of history.

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REFERENCES

- Fleming, John Ambrose. *The Thermionic Valve and its Developments in Radio-Telegraphy and Telephony*. London: Wireless Press Ltd., 1919.
- Blumtritt, Oskar. The Lieben Valve: a German “universal amplifier”, *Deutsches Museum*, June 2004.
- Leggett, Bernard John. *Wireless telegraphy: with special reference to the quenched-spark system*, E.P. Dutton, New York, 1921.
- PATENTSCHRIFT Nr. 71340, Siegmund Strauss, Device for the Production of Electric Oscillations, Entered Dec.1912, Granted June 1915., July 21, 1926.

